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Evaluation of Stocked Rainbow Trout Populations in Interior Alaska, 2006

By

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and

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Alaska Department of Fish and Game **Divisions of Sport Fish and Commercial Fisheries**

Symbols and Abbreviations

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Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
milliliter	mL
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
nautical mile	nmi
ounce	oz
pound	lb
quart	qt
yard	yd

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
degrees kelvin	K
hour	h
minute	min
second	s

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity (negative log of)	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

Alaska Administrative Code	AAC
all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.
all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.
at	@
compass directions:	
east	E
north	N
south	S
west	W
copyright	©
corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
District of Columbia	D.C.
et alii (and others)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.
Federal Information Code	FIC
id est (that is)	i.e.
latitude or longitude	lat. or long.
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S.C.	United States Code
U.S. state	use two-letter abbreviations (e.g., AK, WA)

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
base of natural logarithm	*e*
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	(F, t, χ^2, etc.)
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	*E*
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	$log_{2,}$ etc.
minute (angular)	'
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
variance	
population	Var
sample	var

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ABSTRACT

Stocked rainbow trout populations were sampled in 10 lakes in the Tanana River and Copper River drainages during 2006 to determine if the stocked fisheries program was meeting management objectives. Rainbow trout populations in nine lakes had "regional" management objectives and the population in one lake had "conservative" management objectives. No fish were captured in two of the nine "regional" management lakes. Mean length and relative abundance criteria required to meet "regional" and "conservative" management objectives were calculated for specific length categories and age cohorts using population models that were based on generalized growth curves, survival rates, and preferred stocking strategies. The length categories for "regional" management objectives were < 250 mm and≥ 250 mm. The length categories for "conservative" management objectives were < 460 mm and ≥ 460 mm. Rainbow trout populations were evaluated by comparing mean length and relative abundance statistics obtained from population sampling to the management criteria as well as to predicted values calculated from the actual stocking history.

"Regional" management criteria for mean length were achieved for six out of seven populations for fish < 250 mm FL and for all seven populations for fish ≥ 250 mm FL. Coal Mine #5 Lake failed to achieve the criteria for length category < 250 mm FL.. Criteria for relative abundance by length category or age cohort were not achieved for any of the seven lakes. Age cohorts were determined for only Triangle Lake and West Iksgiza Lake populations and both achieved the criteria for mean length.

"Conservative" management criteria for mean length were achieved for length category and age cohort for the Dune Lake population. Criteria for relative abundance by length category and age cohort were not achieved.

This information, along with ancillary information about lake and fishery characteristics, were used to adjust stocking strategies that specified criteria for the size (length or weight) and number of fish to stock, number of stockings, time of year and whether stockings were biennial or annual. The goal was to create population structures that would meet "regional" or "conservative" management objectives.

A two-sample mark-recapture experiment was conducted on the rainbow trout population in Lisa Lake in 2006 to estimate abundance and to evaluate size sampling bias as a function of differential age class vulnerability to sampling gear. The abundance estimate was 527 (SE=47) age-2 and older rainbow trout. Differential age class vulnerability could not be evaluated because all but one of the fish captured were age 2.

Key words: fish population monitoring, rainbow trout, *Oncorhynchus mykiss*, Backdown Lake, Coalmine Lake, Dune Lake, Firebreak Lake, Jan Lake, Last Lake, Lisa Lake, Tolsona Lake, Triangle Lake, West Iksgiza Lake, population structure, stocking evaluation, stock assessment, stocking method, length at age, mark-recapture sampling bias.

INTRODUCTION

The Alaska Department of Fish and Game (ADF&G) stocks game fish in 134 lakes and one stream in the Tanana River drainage in Interior Alaska and the Upper Copper/Upper Susitna (UCUS) river drainages in the Glennallen area (Figure 1). The goal of the stocked fisheries program is to provide diverse and dependable angling opportunities near population centers and offer alternatives to the harvest of wild fish stocks. The stocked fisheries program began in the early 1950s, when lakes along the road system were stocked with rainbow trout *Oncorhynchus mykiss*, or coho salmon *Oncorhynchus kisutch*. Today, the stocked fisheries program provides year-round sport-fishing opportunity for rainbow trout, coho salmon, Chinook salmon *Oncorhynchus tshawytscha*, Arctic grayling *Thymallus arcticus*, and Arctic char *Salvelinus alpinus*.

The stocked fisheries program has multiple roles and provides many benefits. The program supports consumptive fisheries and creates new angling opportunities along the road system where potential fishing effort is greatest. It also supports rural and remote fisheries where diverse angling opportunity is desired. As a conservation tool, it serves to divert fishing pressure away from wild populations that cannot support high levels of harvest desired by anglers. Anglers and businesses in the Tanana Valley value the stocked fisheries program because it provides angling opportunities that normally would not be present and it benefits local economies through the sales of fishing related sporting goods and guiding services. Anglers particularly enjoy opportunities to catch highly desired species such as rainbow trout and Arctic char which are not native to the Tanana Valley.

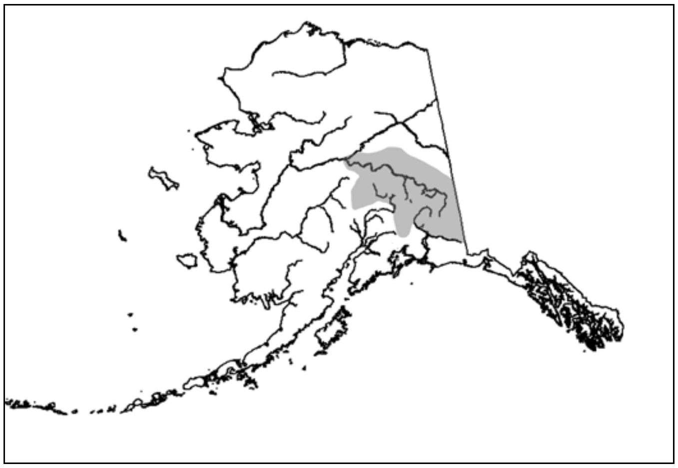

Figure 1.–The Tanana River and Upper Copper/Upper Susitna River drainages (shaded area).

STOCKED WATERS MANAGEMENT PLAN

In 2004 the Board of Fisheries (BOF) adopted two new general management plans for the stocked waters fisheries within Region III (5 AAC 70.065 and 5 AAC 52.065; 2004). The management plans state: "The department shall manage stocked waters in the Arctic-Yukon-Kuskokwim Region [and the Upper Copper River and Upper Susitna River Area] in order to meet public demand for diverse fishing opportunities." The plans outline three management approaches (regional, conservative, and special) and corresponding objectives and regulations for each.

- Regional Management Approach. Under the regional management approach, stocked waters will be managed so that there will be a reasonable expectation of high catch rates and harvesting a daily bag limit. The bag and possession limit is 10 fish in combination of all stocked species, and only one of those fish may be 18 inches (457 mm TL) or greater in length. The fishing season is open year round and bait may be used.
- Conservative Management Approach. Under the conservative management approach, stocked waters will be managed so that there will be a reasonable expectation to catch a daily bag limit with a reasonable chance of catching fish 18 inches (457 mm TL) or greater in length. The bag and possession limit is five fish in combination of all stocked species, and only one of those fish may be 18 inches (457 mm TL) or greater in length. The fishing season is open year round and bait may be used.
- Special Management Approach. Under the special management approach, stocked waters will be managed so that there will be a high probability of an angler catching more

than one fish a day that is 18 inches (457 mm TL) or greater in length. When considering a proposal regarding this management approach, the board should consider taking the following actions:

(1) limit fishing;

  (A) catch-and-release fishing;

  (B) fly fishing;

  (C) trophy fishing, which means that a fish retained must be 18 inches or greater in length;

(2) establish seasonal periods when fishing is closed or is restricted to catch-and-release fishing; or,

(3) establish a bag limit of one fish, 18 inches (457 mm TL) or greater in length, or another appropriate bag and size (length) limit.

Stocked Waters Program Assessment

ADF&G will need to focus on anglers in the future to directly assess their understanding of the three management approaches, their expectations, and whether their expectations are being met. ADF&G is currently stocking fish at levels that are less than desirable and fishery managers must contend with numbers of fish, sizes, and production schedules that don't meet angler needs. Direct evaluation of success in meeting management objectives should be suspended until 2012 after a new fish hatchery in Fairbanks is producing fish. Efforts to directly survey anglers now will only serve to evaluate an interim sub-desirable condition.

By 2012, as hatchery production increases, a survey of anglers will provide information needed by managers to directly assess the stocked fisheries program. For now, defining and using population structure as the objective for each of the three management approaches is an indirect but reasonable approach to assessing the stocked fisheries program.

POPULATION STRUCTURE AND STOCKING STRATEGY

Each management approach lists general objectives for numbers and sizes of fish that anglers should have a reasonable expectation to catch and harvest. To meet these objectives, we designed a general population structure for each management approach that would provide a reasonable opportunity for an angler to catch and harvest the sizes and numbers of fish described in each approach.

To determine what size fish would meet anger's expectations, we conducted informal interviews with anglers and biologists. There was general agreement that most anglers would be "satisfied" catching a rainbow trout that was at least 250 mm (FL) and the minimum length for a "quality" fish was 460 mm.

Using these sizes for guidance we decided that a population structure emphasizing average size fish from 200 mm to 350 mm was reasonable for the Regional Management approach which focused on a high catch rate and liberal bag limit. For the Conservative Management approach we proposed a population structure having fish from 350 mm to 500 mm and for the Special Management approach we would emphasize fish larger than 400 mm. The goal for the last two approaches was to provide a greater proportion of large or "quality" fish in the population.

However, there are fewer fish in these populations compared to fish populations managed under the Regional Management approach and harvest is more restrictive.

A model was used to generate the abundances and length distributions for the various age cohorts that made up a population structure. The abundance and length distribution for an age cohort were calculated using generalized values for survival rate-at-age and length-at-age which were obtained from a review of the literature, past experience, and results from recent population studies. Survival rate-at-age and length-at-age were specific to each management approach (Table 1).

Table 1.–Generalized survival rate-at-age and length-at-age for Regional, Conservative, and Special management approaches.

Approach	Age 1	Age 2	Age 3	Age 4	Age 5
Regional					
Survival	0.10	0.40	0.40	0.20	0.10
Length (mm)	210	300	370	410	450
Conservative					
Survival	0.10	0.50	0.50	0.40	0.40
Length (mm)	230	320	390	440	480
Special					
Survival	0.10	0.60	0.60	0.50	0.40
Length (mm)	250	340	410	460	500

A stocking strategy was then developed for each fishery that would produce the desired population structure. A stocking strategy had goals for the size (length or weight), number of fish to stock, number of stockings each year, time of year, and whether stockings were annual or biennial. These strategies were then used to determine production schedules for ADF&G fish hatcheries.

FISHERY-SPECIFIC MANAGEMENT CRITERIA

The population structures we designed for each fishery were used as quantitative targets to measure the success of the stocked fisheries program. The successful creation and maintenance of a population structure was used as a surrogate to indicate that we successfully met the management approach objectives.

To compare the observed population structures to the target (management) population structures, we established criteria for mean length and relative abundance for each rainbow trout population based on length categories and age cohorts. The length categories for the Regional Management Approach were < 250 mm and ≥ 250 mm. The length categories for the Conservative and Special Management Approaches were < 460 mm and ≥ 460 mm along with secondary length categories of < 250 mm and ≥ 250 mm. Mean length and relative abundance were calculated using the management population structures for each fishery.

Because actual stockings were not consistent and often failed to meet all strategy goals for number and size of fish, the observed population structures were also compared to mean length and relative abundance criteria that were predicted from the actual stocking history for each lake.

SINGLE-SAMPLE FISH POPULATION MONITORING

In 2006, rainbow trout populations in 10 lakes were selected for evaluation. Nine lakes had "regional" management objectives and one lake had "conservative" management objectives.

OBJECTIVES

Management Objective 1: Determine if fish populations were achieving the "management" length-age structures for the rainbow trout populations listed in Table 2.

Research Objective 1: Test the null hypothesis that mean length of rainbow trout within defined length categories and age cohorts does not differ from the predicted value with 90% power of rejecting the null hypothesis if the true mean length differs from the predicted value by more than 10% using alpha = 0.10.

Research Objective 2: Test the null hypothesis that the proportion of rainbow trout within defined length categories and age cohorts does not differ from the predicted value with 80% power of rejecting the null hypothesis if the true proportion differs from the predicted value by more than 10 percentage points using alpha = 0.20.

METHODS

SAMPLING PROCEDURE

Fish populations in 10 stocked lakes near Fairbanks, Delta Junction, and Glennallen were sampled to determine the population length-age structure (Table 2; Figures 2, 3, and 4). Fyke nets and tangle nets were used to capture fish.

Fyke nets were set near shore on the lake bottom in 1 to 2 m of water. Fyke nets had square openings that were either 0.9 or 1.2 m^2, the length from square opening to cod end was about 5 m, hoop size for the net body was 0.9 m diameter, and mesh size was 9 mm^2. Wings measuring 7.5 m long by 1.2 m deep were attached to each side of the open end. The net body was positioned parallel to shore and the wings set to form a "V". Each fyke net was pulled taut from the cod end and held in position with a weight.

Table 2.–Description of rainbow trout fisheries to be sampled in 2006.

Fishery	Hectare (Acre)	Management Category	Stocking Frequency
Backdown Lake	2 (6)	Regional Management	alternate – even year
Coalmine #5 Lake	5 (13)	Regional Management	alternate – even year
Dune Lake	72 (179)	Conservative Management	alternate – odd year
Firebreak Lake	40 (100)	Regional Management	alternate – odd year
Jan Lake	18 (45)	Regional Management	alternate – even year
Last Lake	2 (5)	Regional Management	alternate – even year
Lisa Lake	20 (50)	Regional Management	alternate – even year
Tolsona Mt. Lake	30 (75)	Regional Management	alternate – even year
Triangle Lake	43 (106)	Regional Management	alternate – odd year
West Iksgiza Lake	33 (81)	Regional Management	alternate – odd year

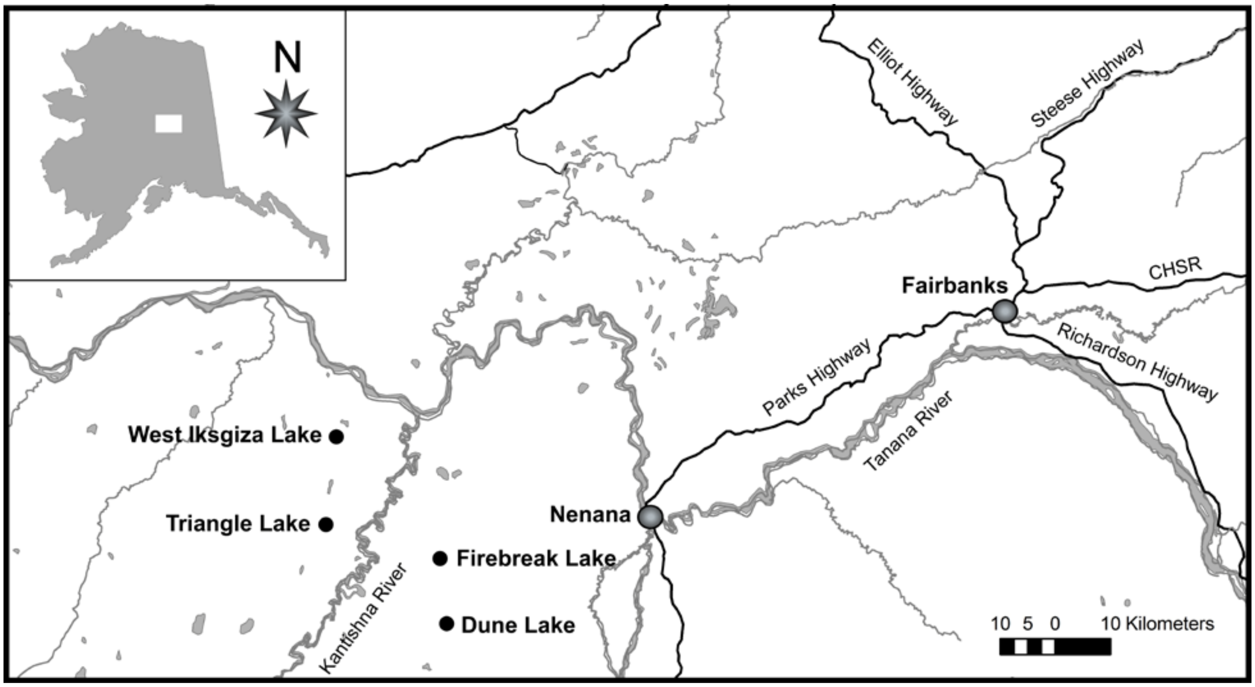

Figure 2.–Lower Tanana Management Area (Fairbanks) - stocked lakes sampled in 2006.

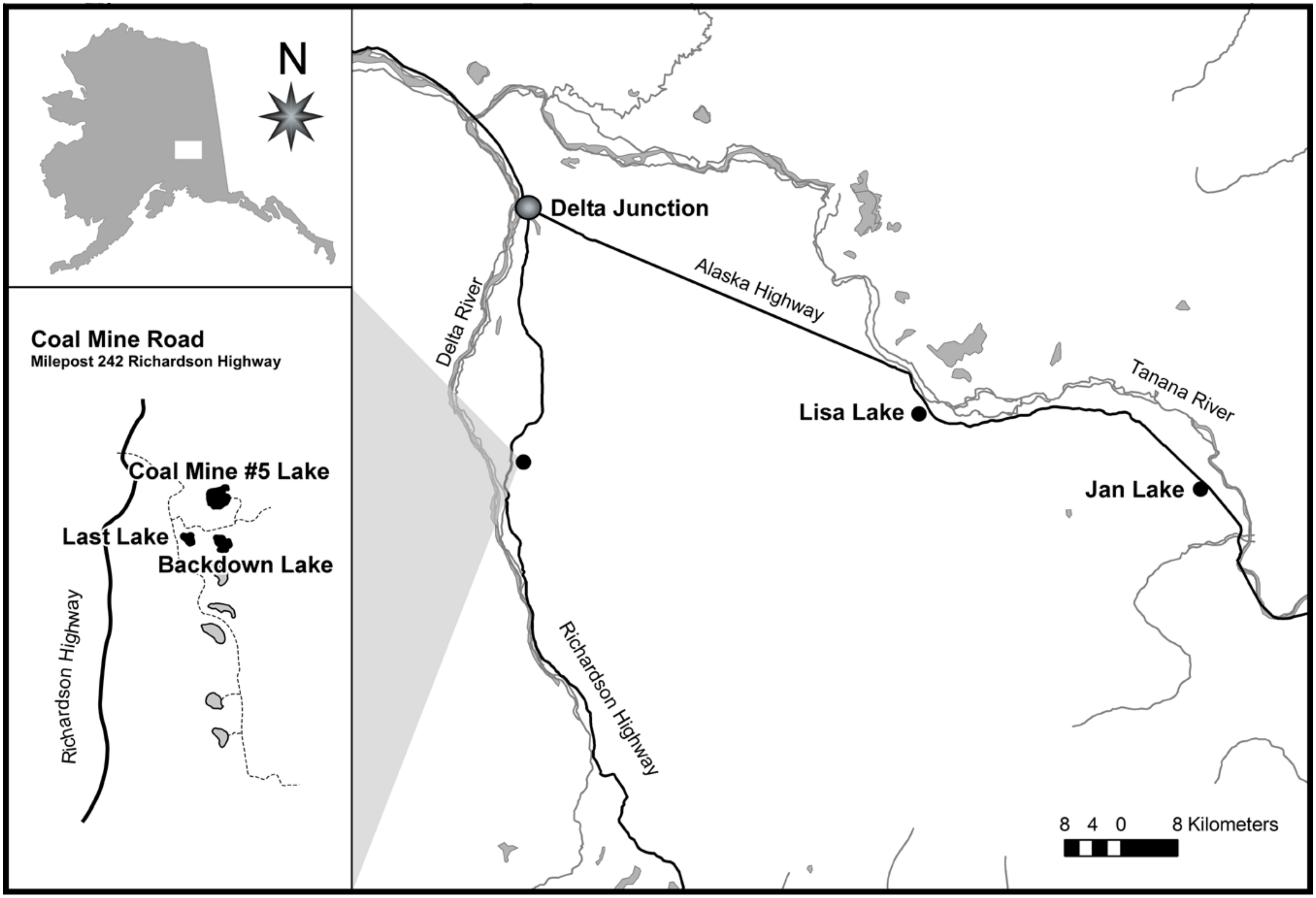

Figure 3.–Upper Tanana Management Area (Delta) - stocked lakes sampled in 2006.

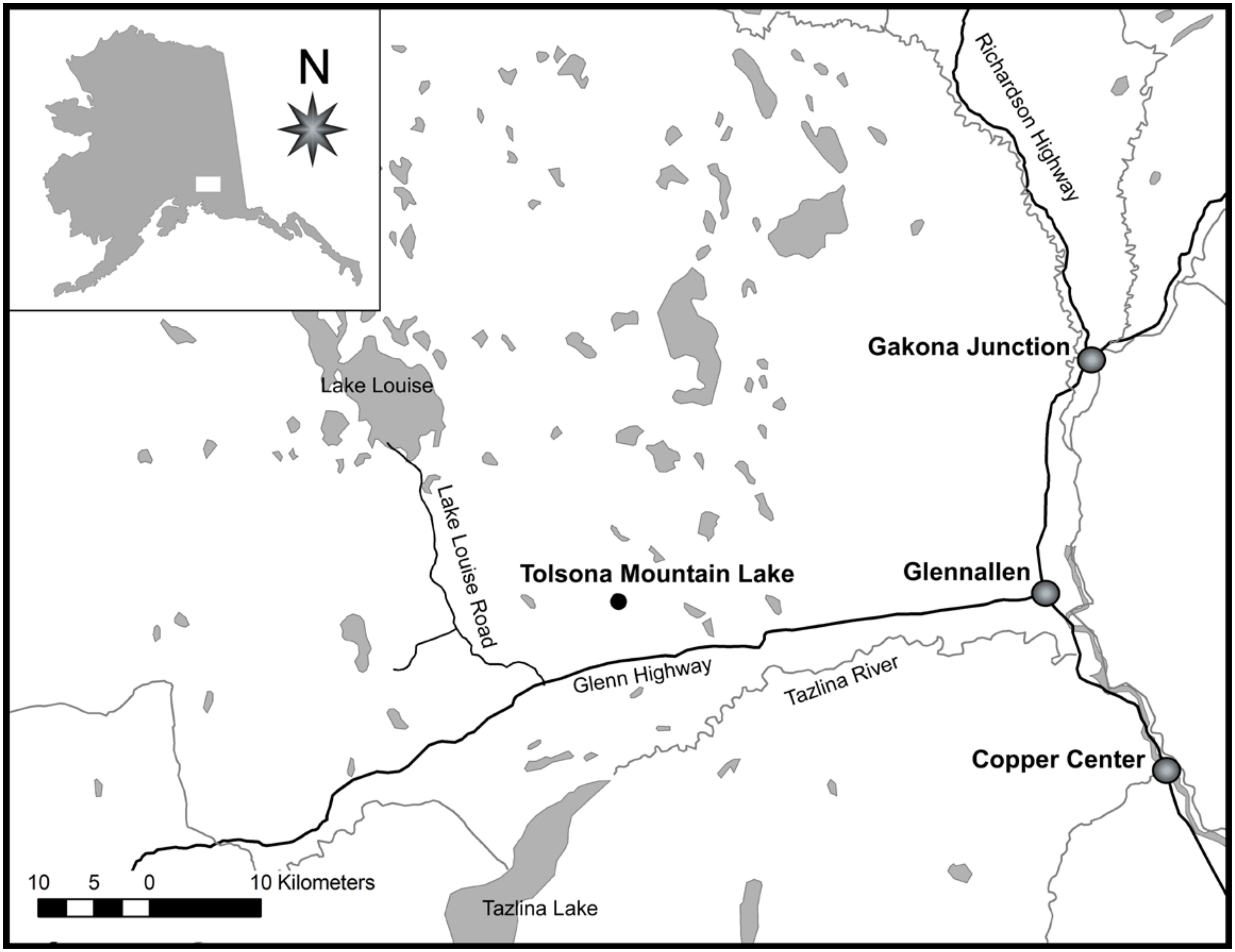

Figure 4.–Upper Copper Upper Susitna Management Area (Glennallen) - stocked lakes sampled in 2006.

Tangle nets were set perpendicular to shore in water deeper than 2 meters. Tangle nets measured 45 m (150 ft) long by 5.4 m (18 ft) deep and were made of 13 mm (½ in) bar fine thread monofilament. Mesh size was small to ensure that fish were captured by entanglement around the mouth and not by the gill covers. Two styles of nets were used. One net was a "floater" - the float line buoyancy was greater than the weight of the lead line. The other net was a "sinker" - the lead line was weighted to overcome the buoyancy of the float line. The "floater" had a triple float line and 13.5 kg (30 lb) lead line. The "sinker" had a double float line and a 31.5 kg (70 lb) lead line. Generally, tangle nets were checked every 20 minutes. The time was then shortened or extended depending on an immediate assessment of the condition of the fish by the field crew leader.

Hoop traps were 0.5 m diameter and 1.6 m long with an inward pointing conical funnel at one end. Netting was 6.4 mm Delta weave. Hoop traps were used in water deeper than 2 m. Each hoop trap was attached to a vertical line with a float on one end and a weight on the other. Traps were oriented horizontally (the long axes of the hoop trap parallel to the surface) and baited with unsalted salmon roe. Hoop traps were not set in depths where dissolved oxygen levels were less than 2 ppm.

The amount of capture gear and the duration of sampling projects were based on lake size (Table 3). In larger lakes, more capture gear was used and the duration of the project was increased. Sampling was stopped at the end of the allotted time even when a sample size was not achieved.

Table 3.–Amount of capture gear and duration of sampling project by lake size.

Hectare (Acre)	Days	Fyke Nets	Tangle Nets	Hoop Traps
0 to 20 (50)	1	4	1	5
>20 to 40 (100)	2	4	1	5
>40 to 200 (500)	3	4	2	8
>200 to 400 (1,000)	3	6	2	10
>400 (1,000)	3	8	2	10

All captured fish were measured to the nearest mm FL. Fish captured for the first time regardless of gear type were marked by removing a half circle of tissue from the trailing edge of the upper lobe of the caudal fin. The mark was made with a paper punch that produced a 7 mm diameter circular hole. Subsequent recaptures were recorded but the data were not used for analysis.

When more than 50 fish were captured, a spearmint oil and ethanol mixture was used to anesthetize up to 50 fish at a time in a water bath. The spearmint concentration in the water bath was 100 mg/l. This made the fish easier to handle and minimized injuries to the fish that might result from having to physically subdue an active fish.

Water temperature was monitored daily 1 m beneath the surface and all sampling was conducted when water temperature was < 18°C.

DATA REDUCTION AND ANALYSIS

Sample data were used to enumerate rainbow trout within specific length categories and to generate length frequency distributions (LFDs) for each rainbow trout population. When possible, age cohorts were identified by visual inspection of LFD plots and the corresponding mean lengths were calculated using the appropriate length data.

The length or age composition of each rainbow trout population was calculated using (Cochran 1977):

$$\hat{p}_k = \frac{y_k}{n} \tag{1}$$

where:

$\hat{p}_k$ = the proportion (relative abundance) of rainbow trout that belong to length category or age cohort k;

y_k = the number of rainbow trout sampled that belong to length category or age cohort k; and,

n = the total number of rainbow trout sampled.

The unbiased variance of this proportion was estimated as:

$$\hat{V}(\hat{p}_k) = \frac{\hat{p}_k(1-\hat{p}_k)}{n-1} \tag{2}$$

Observed mean lengths and sampling variances within specific size categories and age cohorts were calculated using standard sample summary statistics (Cochran 1977).

For visual comparison, LFDs generated using sample data were plotted with the corresponding population curves that were generated from the management and predicted population structures. For each population the observed number of rainbow trout that belonged to a specific size category or age cohort (relative abundance) was compared to numbers corresponding to the management criteria and to the predicted criteria using χ^2 goodness of fit tests (Zar 1984). Observed mean lengths were compared to mean lengths for management and predicted criteria for the same specific size category or age cohort using single-sample t-tests (Zar 1984). The χ^2 goodness of fit tests were evaluated using $\alpha = 0.20$ and the t-tests were evaluated using $\alpha = 0.10$.

Management and predicted criteria were considered achieved when the observed mean length or relative abundance was not statistically different from the criteria or, if statistically different, the difference was ≤ 0.10 for relative abundance or ≤ 25 mm for mean length. We considered these differences not meaningful to anglers. Management and predicted criteria were also considered achieved when the observed mean length was larger than the criteria regardless of statistical significance.

ASSUMPTIONS AND BIAS

One potential concern with using data from this single-sample study design is that inadequate data are collected to evaluate size bias during sampling. An accurate estimate of a population LFD requires that all fish in a population have the same probability of capture. In practice this likely does not happen and this assumption cannot be evaluated with a single-sample capture-event. A review of the literature and previous mark recapture studies conducted by ADF&G indicate that potential bias may be minimized by avoiding sampling activities during high water temperatures, by sampling different habitat areas, and by using gear that is not size selective.

Researchers have found that water temperature influences rainbow trout distribution in lake systems, and have documented movement of rainbow trout from nearshore to offshore habitats when water temperature exceeds 20°C (Horak and Tanner 1964; Overholtz et al. 1977; Rowe and Chisnall 1995; Rowe 1984). Doxey (1989, 1992; M. Doxey, Sport Fish Biologist, Retired, ADF&G, Fairbanks; personnel communication) noted an influx of rainbow trout to shallow near shore areas as water temperature dropped during fall sampling activities conducted at Birch Lake, Alaska. Researchers have also noted that rainbow trout preferred depths of 0-4 m in the spring, and avoided shallow water as temperature increased throughout the summer (Overholtz et al. 1977). Additionally, a study conducted by Kwain and McCauley (1978) found that older rainbow trout have a lower temperature preference than do younger fish. Based on these findings, we concluded that larger fish will likely be the first to seek thermal refuge offshore as water temperature in littoral areas increases. To minimize the potential for size bias sampling due to this phenomenon, all sampling during our study was conducted when water temperature 1 m beneath the surface was < 18°C.

Although we expected rainbow trout populations to be distributed nearshore when water temperature was < 18°C, we sampled both nearshore and offshore habitats to verify the presence or absence of fish in both areas. Previous studies conducted by ADF&G (under similar thermal conditions) found that capture rates for rainbow trout in offshore tangle nets, fyke nets, and hoop traps were lower than those for nearshore fyke nets (Fish and Skaugstad 2004; Havens et al. 1992; Behr and Skaugstad *In prep*). Warner and Quinn (1995) found that radio-tagged rainbow trout in Lake Washington were predominantly found in nearshore areas and resided in the top 3 m of the water column 90% of the time during sampling conducted in June, August, September, and October. Similarly, approximately 88% of all rainbow trout caught during sampling activities in 2005 were captured in nearshore fyke nets (Behr and Skaugstad *In prep*).

To minimize the potential for size bias due to capture gear, we used fyke nets and 13 mm (½ in) bar, fine thread, monofilament tangle nets during our study. Fyke nets are typically fished in shallow waters and have proven effective at catching rainbow trout 50 to > 600 mm (Skaugstad and Behr *In prep*; Behr and Skaugstad 2006; Fish and Skaugstad 2004). The length of fish captured in tangle nets is variable and depends on mesh size; however, a 13 mm mesh should be sufficient to capture age-1 and older fish in stocked lakes.

The sampling methods used in this study were similar to those used in previous two-sample mark-recapture experiments conducted by ADF&G in which size bias was examined using either Kolmogorov-Smirnov (K-S) tests (Conover 1980) or chi-square contingency table analyses (Seber 1982). Robust and objective evaluation of size biased sampling is problematic, at best, when fish grow between sampling events. In Interior Alaska, average growth rates of nearly 1 mm per day have been observed for rainbow trout during summer (Doxey 1989).

We reviewed several previous experiments to evaluate the relation between detected size bias during rainbow trout sampling and water temperature. In two-sample experiments where a hiatus of more than two weeks occurred between sampling events (allowing for substantial growth), we re-analyzed experimental data using methods described in Behr and Skaugstad

(2006), where unambiguous testing for size bias could only be conducted for first event sampling. In other experiments, where necessary, data were reanalyzed to test for size bias during both sampling events using methods described in Behr et al. (2005). These results may differ from published results in some cases, as we analyzed size data from all rainbow trout captured during these experiments, not just the target age classes.

In 2004, two mark-recapture experiments were conducted at Koole and Rainbow lakes to estimate the abundance of rainbow trout. Sampling procedures for both experiments were similar to those for this study, except that hook-and-line gear was used to supplement catches at both lakes and hoop nets were used at Rainbow Lake. K-S test results indicated that no significant size bias occurred during the first sampling event at Koole Lake, where the maximum water temperature recorded was 14°C at a depth of 0.3m during June 7–11 (Behr *Unpublished*). Similarly, no significant size bias was detected for the first sampling event at Rainbow Lake where the highest water temperature recorded was 17.7°C at a depth of 0.5m on 25 August (Behr and Skaugstad 2006, Behr *Unpublished*). During Events 1 and 2, 97% and 99% of samples, respectively, were caught in fyke traps. Age-0 rainbow trout that were stocked in Rainbow Lake prior to sampling and subsequently captured in fyke nets were not used in mark-recapture experiment. Usually the smallest age-0 fish can escape through the fyke net mesh and they are subject to predation by larger fish in the fyke nets. This situation will likely result in an observed probability of capture that is significantly different from that for the other age cohorts. Consequently, age-0 fish were enumerated and measured during population sampling but the data were not used to generate information about population structure.

Only nearshore fyke nets were used during a two-sample mark-recapture experiment conducted in mid-June and mid-August of 2001 at Lisa Lake. K-S test results indicated that size bias for rainbow trout captured during the first event was not significant (Behr et al. 2005). Water temperature during mid-June was 17.5°C 1 m beneath the surface (Behr *Unpublished*). In September and October of 2006 a second mark-recapture experiment was performed at Lisa Lake. Offshore tangle nets and nearshore fyke nets were used during both events, and K-S test results indicated that no significant size bias occurred (Two Sample Fish Population Monitoring). Water temperatures at 1 m beneath the surface were 11.1°C during Event 1 and 5.5° during Event 2 (Behr *Unpublished*).

In 2000, four two-sample mark-recapture experiments were conducted at Dune, Bluff Cabin, Donna, and Little Donna lakes (Skaugstad and Fish 2002). Fyke nets, tangle nets, and hook-and-line gear were used. Sampling was conducted in June and August. Reanalysis of rainbow trout mark-recapture data for Dune Lake provided no significant evidence of size bias sampling during Event 1 ($p = 0.972$) where the water temperature was 16.3°C at a depth of 1.0 m on June 15 (the last day of sampling; Behr *Unpublished*). Reanalysis of Donna Lake data provided no significant evidence size bias sampling during either Event 1 ($p = 0.196$) or Event 2 ($p = 0.772$). Water temperature was about 10.5°C at a depth of 1 m on August 31 (first day of Event 2 sampling; Behr *Unpublished*). Similar results were obtained from data from Little Donna Lake for both Event 1 ($p = 0.425$) and Event 2 ($p = 0.978$). While sampling at Little Donna Lake occurred during the same time frame as at Donna Lake, no water temperature data were available. In contrast, reanalysis of Bluff Cabin Lake data indicated significant size bias sampling during both Event 1 ($p < 0.001$) and Event 2 ($p = 0.001$) where the water temperature was 17.2°C at a depth of 1.0 m and 18.6°C at a depth of 0.5 m on June 6 (the first day of sampling) (Behr *Unpublished*).

Two-sample mark-recapture experiments were performed at Quartz Lake in 2001 to estimate the abundance of age-1 rainbow trout and in 2002 to estimate the abundance of age-2 and older rainbow trout (Fish and Skaugstad 2004). Nearshore and offshore fyke nets, hoop nets, and tangle nets were used in 2001 and sampling was conducted May 29 to June 1 (Event 1) and June 18 to 22 (Event 2). Reanalysis of these data indicated significant size bias sampling during both Event 1 ($p < 0.001$) and Event 2 ($p < 0.001$) where the water temperature was 11°C at a depth of 1 m on May 31 and 20°C at a depth of 1 m on June 22 (Behr *Unpublished*). Less than 1% of the rainbow trout were caught in floating fyke nets, hoop nets, and tangle nets deployed in water > 1 m in depth. In 2002, fyke nets and tangle nets were used and sampling was conducted in September. Reanalysis provided no significant evidence of size bias sampling during either Event 1 ($p = 0.384$) or Event 2 ($p = 0.493$). Water temperature was not recorded during sampling but typically lake temperatures have cooled to < 14°C 1 m below the surface by September. Rainbow Lake (16 km from Quartz Lake) was < 12°C 1 m below the surface in mid-September (Behr *Unpublished*). During Event 1 no rainbow trout were caught in tangle nets in deep water and during Event 2 16% of the fish sampled were caught in tangle nets. The size distributions of fish captured with all gear types during Event 1 and Event 2 were not statistically different ($p = 0.734$).

Of the studies reviewed, only one result was inconsistent with our prescription to restrict sampling to when water temperature is < 18°C in order to minimize potential for size biased sampling of rainbow trout. Significant size bias sampling was detected during Event 1 sampling at Quartz Lake in 2001, when water temperatures was 11°C (Behr *Unpublished*). Probability of capture of rainbow trout 170 mm and larger (age 2 and older) was greater than that of smaller rainbow trout (age 1). During Event 1 the larger rainbow trout were concentrated in a few nearshore areas for spawning and later, during the hiatus and Event 2, dispersed throughout the lake. Researchers realized that spawning behavior in spring would likely affect the capture probability of age-2 and older rainbow trout during the course of the study; however, they were interested only in estimating the abundance of age-1 rainbow trout. Future studies of the Quartz Lake rainbow trout population using single-sample methods to estimate relative abundance should be conducted in fall to avoid capture heterogeneity between different size/age cohorts.

Detecting capture heterogeneity when sampling small populations (< 2000 fish) is very difficult. The K-S test is typically used during two-sample mark-recapture experiments to detect size bias sampling during either sampling event and to guide model selection for estimating abundance and composition. To estimate the power of the K-S test to detect size bias sampling in small populations, we constructed artificial populations of two age classes (age 1 and 2) of rainbow trout based on length-at-age data from previous experiments (ADF&G unpublished data). Population size varied from 500 to 2000 fish, and within each population the proportion of age-2 fish was varied from 20% to 66%. We simulated two-event mark-recapture sampling on these populations with sufficient sampling intensity to estimate abundance within 20% of the true value 95% of the time (assuming no size bias during sampling). We simulated probability of capture for age-2 fish to be 50% of the probability of capture of age-1 fish during both sampling events, and simulated this size bias sampling during only Event 1 with no size bias during Event 2. We conducted K-S tests using simulated data to detect capture heterogeneity and estimated power by evaluating the frequency when size bias sampling was concluded. The results from capture heterogeneity during both events and during Event 1 are reported in Tables 4 and 5 respectively. When capture heterogeneity was simulated during both sampling events, the power of the K-S tests was poor (< 1% to 30%) when the segment of the population with lower capture probability comprised 50% or less of the population when using $\alpha = 0.05$ as the rejection criteria for the test. When $\alpha = 0.20$ was used as the rejection criteria, power was still poor (<1% to 26%) when the segment of the population with lower capture probability comprised 33% or less of the population. In simulations where capture heterogeneity occurred only during Event 1, the power of the K-S test was poor (< 1% to 29%) when the segment of the population with lower capture probability comprised 33% or less of the population when using $\alpha = 0.05$ as the rejection criteria. When $\alpha = 0.20$ was used as the rejection criteria, power was still poor (< 9% to 23%) when the segment of the population with lower capture probability comprised 20% or less of the population.

Table 4.–Power of Kolmogorov-Smirnov (K-S) test to detect capture heterogeneity in small populations during two-sample mark-recapture studies designed to estimate true abundance within 20% of the true value 95% of the time, where ***x***% of the population has 50% of the capture probability of the remainder of the population during both sampling events. Results based on 10,000 simulations of two age classes of fish with adjacent but non-overlapping bell shaped length distributions and ***x***% represents one entire age class.

		Mean		Power of RvC & MvC K-S tests		
N	***x***%	M & C	R	$\alpha = 0.05$	$\alpha = 0.10$	$\alpha = 0.20$
500	0.20	157	52	<0.01	<0.01	0.02
750	0.20	204	58	<0.01	<0.01	0.03
1000	0.20	245	63	<0.01	0.01	0.04
1500	0.20	313	69	<0.01	0.02	0.05
2000	0.20	372	73	<0.01	0.02	0.06
500	0.33	158	54	<0.01	0.03	0.08
750	0.33	205	60	0.02	0.05	0.13
1000	0.33	244	64	0.02	0.06	0.16
1500	0.33	313	71	0.03	0.09	0.21
2000	0.33	373	75	0.05	0.12	0.26
500	0.50	157	55	0.08	0.19	0.37
750	0.50	204	62	0.14	0.27	0.46
1000	0.50	244	66	0.19	0.33	0.53
1500	0.50	313	73	0.26	0.42	0.61
2000	0.50	371	76	0.30	0.46	0.65
500	0.66	157	56	0.26	0.43	0.61
750	0.66	205	63	0.36	0.53	0.70
1000	0.66	245	67	0.44	0.61	0.76
1500	0.66	314	74	0.54	0.69	0.81
2000	0.66	372	78	0.59	0.73	0.84

Table 5.–Power of Kolmogorov-Smirnov (K-S) test to detect capture heterogeneity in small populations during two-sample mark-recapture studies designed to estimate true abundance within 20% of the true value 95% of the time, where ***x***% of the population has 50% of the capture probability of the remainder of the population during first event sampling and no capture heterogeneity occurs during second event sampling. Results based on 10,000 simulations of two age classes of fish with adjacent but non-overlapping bell shaped length distributions and ***x***% represents one entire age class.

		Mean		Power of RvC K-S test		
N	***x***%	M & C	R	$\alpha = 0.05$	$\alpha = 0.10$	$\alpha = 0.20$
500	0.20	157	49	<0.01	0.03	0.09
750	0.20	204	56	0.01	0.04	0.13
1000	0.20	245	60	0.02	0.06	0.16
1500	0.20	313	65	0.03	0.09	0.21
2000	0.20	373	69	0.04	0.11	0.23
500	0.33	158	50	0.08	0.18	0.35
750	0.33	205	56	0.12	0.25	0.43
1000	0.33	244	59	0.17	0.32	0.49
1500	0.33	313	65	0.24	0.39	0.57
2000	0.33	373	70	0.29	0.44	0.61
500	0.50	157	49	0.24	0.39	0.57
750	0.50	204	55	0.34	0.49	0.67
1000	0.50	244	60	0.40	0.55	0.71
1500	0.50	313	65	0.48	0.63	0.77
2000	0.50	371	69	0.53	0.67	0.80
500	0.66	158	50	0.24	0.39	0.57
750	0.66	204	56	0.34	0.50	0.66
1000	0.66	244	60	0.39	0.55	0.70
1500	0.66	314	65	0.48	0.63	0.77
2000	0.66	372	69	0.53	0.67	0.80

The levels of capture heterogeneity sufficient to cause concern when interpreting composition proportions (detecting large fish 50% as often as smaller fish) are not likely to be detected during reasonably well designed two-sample experiments on small populations with age structures similar to what are usually encountered. The fairly poor power of widely used diagnostics tests under these conditions emphasizes the need to identify the field conditions where the chances of size bias sampling occurring can be minimized.

For our studies, the bias introduced by unequal capture probabilities for the different length-age cohorts have different effects on estimating length frequency mode location and mode amplitude. Mode location is important for determining the mean length of length-age cohorts while mode amplitude is important for determining the relative abundance of the length-age cohorts in the population. The bias caused by unequal capture probabilities when estimating mode location will be minimal when individuals in each length-age cohort have the same capture probability (i.e., capture probabilities are the same within cohorts but may be different between cohorts).

Bias will likely have a greater influence on estimating mode amplitude and, thus, on estimating proportions of fish in different length-age categories (i.e., relative abundance). Different capture probabilities between length-age cohorts will result in catches that are not representative of cohort abundance in the population. Increasing the sample size will make the modes more prominent but it will not improve the accuracy of the estimate. However, our review of other studies has shown that the likelihood of size bias is low when sampling is restricted to periods when water temperature is < 18°C. It is anticipated that two-sample mark-recapture studies will be conducted periodically for the larger lakes which are stocked on an annual basis and support a number of age cohorts. We will continue to use information from these studies to evaluate potential size bias associated with single-capture sampling.

RESULTS AND DISCUSSION

Water temperature 1 m beneath the surface remained < 18°C during population sampling. No adverse weather conditions, high winds or waves occurred during sampling. For the 10 rainbow trout populations surveyed, about 98% of all sampled rainbow trout were captured in fyke nets and 2% in tangle nets (Appendix A).

Visual identification of age cohorts using population LFDs was easy for populations maintained with biennial stockings because the LFDs for individual cohorts didn't overlap. However, when stockings happened every year the overlap of individual cohort LFDs was more extensive making the cohorts less discernible. For populations supported with annual stockings, separating cohorts using visual identification was not useful for age-2 and older cohorts.

REGIONAL MANAGEMENT LAKES

Backdown Lake

Backdown Lake is located along the Coal Mine Road 35 km South of Delta Junction at Kilometer 390.4 (Mile 242.4) of the Richardson Highway (Upper Tanana Management Area; Figure 3). The lake covers 2.4 surface ha and was first stocked with rainbow trout fingerlings in 1987. Rainbow trout captured during this experiment had been stocked biennially since 2002 (Appendix B). Fingerling stockings varied from approximately 1,000 to 1,500 fish. In addition to fingerlings, about 325 subcatchables were stocked in 2004. This fishery does not appear in the Statewide Harvest Survey (Jennings *et al., In prep*) because there were too few respondents to provide reliable harvest estimates.

Population sampling was conducted June 5–7, 2006 and 52 rainbow trout (Figure 5) and 23 Arctic char (Figure 6) were captured. Visual comparison of the observed LFD to management and predicted population structures showed rainbow trout were smaller than expected. Age cohorts were not apparent which could have been the result of either low population abundance, small sample size, or both.

Differences between the observed population structure and management and predicted mean lengths for size category ≥ 250 mm were not statistically significant (Table 6). All other differences were statistically significant for both relative abundances and mean lengths. Management and predicted criteria were met only for mean lengths for size categories ≥ 250 mm. The small sample size (n = 2) for this size category was inadequate to draw reliable inferences about the population structure. No tests were done for age cohorts.

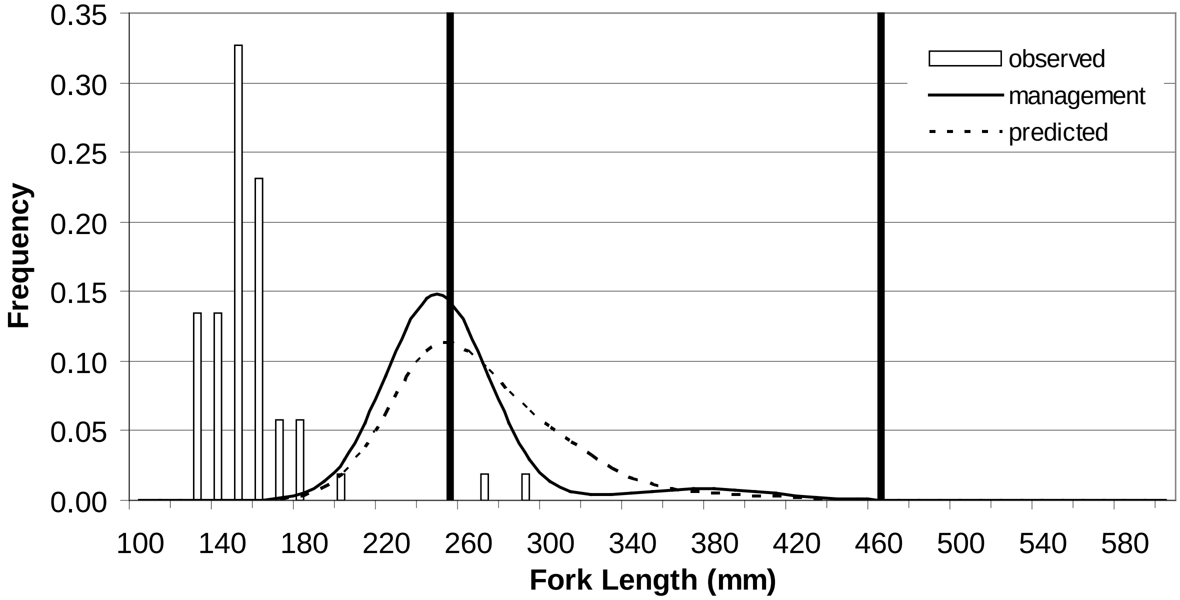

Figure 5.–Backdown Lake: observed rainbow trout length frequency distribution compared to management and predicted criteria, 2006 (n = 52).

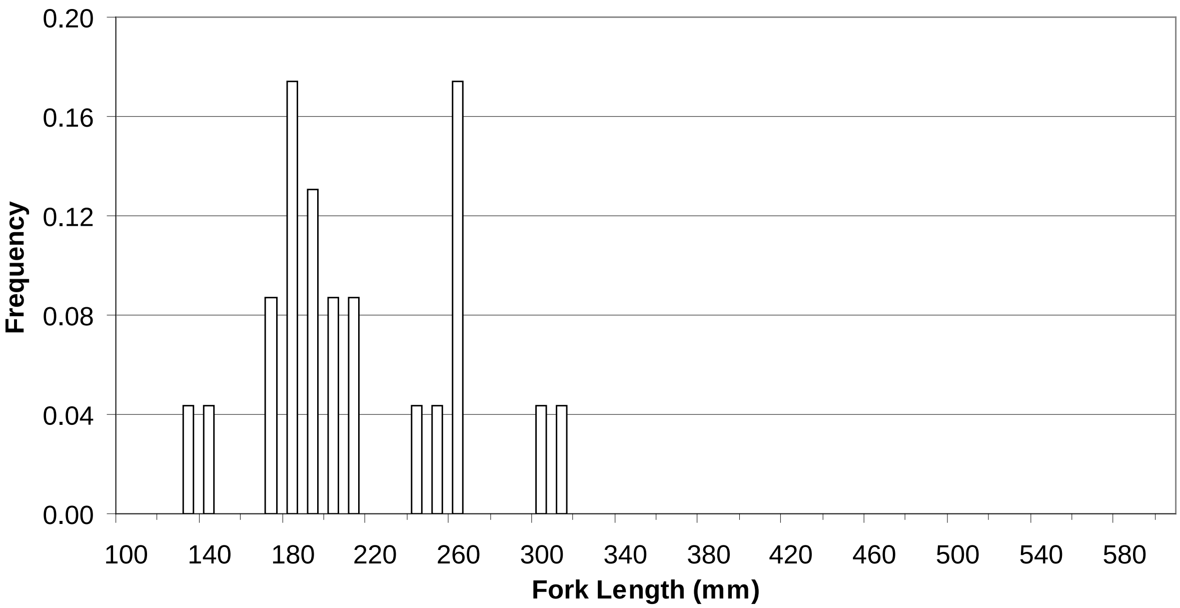

Figure 6.–Backdown Lake: observed Arctic char length frequency distribution, (n = 23).

The stocking history and population model predicted that the expected population abundance was less than 100 rainbow trout age-2 and older. The number of rainbow trout captured also indicated the population abundance was small. During field work the project biologists didn't observe any obvious cause that would explain why the population length structure was smaller than expected. The fish appeared healthy. Project biologists and anglers had noted over several years that the lake surface area had diminished and former shallow areas (< 1 m deep) were dry during this study. Loss of the shallow areas could have resulted in less food available for the fish.

Table 6.–Backdown Lake: test results by length category.

	Relative Abundance (χ^2 test)		**Mean Length** (t test)	
	<250 mm	≥250 mm	<250 mm	≥250 mm
Observed	50	2	148 mm	276 mm
	(0.96[a])	(0.04[a])	(1.97[b])	(13.5[b])
Management Criteria	24	28	225 mm	280 mm
	(0.46[a])	(0.54[a])		
Test Stat		52.6	-39.2	-0.30
DF		1	49	1
P Value		<0.0001	<0.0001	0.82
Predicted Criteria	17	35	225 mm	287 mm
	(0.33[a])	(0.67[a])		
Test Stat		93.8	-39.2	-0.81
DF		1	49	1
P Value		<0.0001	<0.0001	<0.56

[a] Proportion of catch.
[b] Standard error.

Backdown Lake: population length-age structure

	Length Category		Age Cohort			
	< 250 mm	≥ 250 mm	1	2	3	4
Mean Length(FL)	225 mm	280mm	125mm	245mm	320mm	374mm
Relative Abundance	0.46	0.54	0.00	0.93	0.00	0.07

Notes: Values in the table were calculated for even years. Values for odd years will be different. Mean lengths for age cohorts were calculated for spring.

Recommended Actions

- Biennial stockings of 1,200 fingerling rainbow trout (2 g) by mid-June.
- Examine lake conditions to determine if a new stocking scheme would increase fish abundance and length/age structure.
- Assess the population structure in 2010 or 2011 to determine if the biennial (or new) stocking scheme is meeting population structure objectives for regional management.

Coal Mine #5 Lake

Coal Mine #5 Lake is located along the Coal Mine Road 35 km south of Delta Junction at Kilometer 390.4 (Mile 242.4) of the Richardson Highway (Upper Tanana Management Area; Figure 3). The lake covers 5 surface ha and was first stocked with rainbow trout fingerlings in 1989. Rainbow trout captured during this experiment were stocked in 2001 (2,000 fingerlings) and 2004 (2,000 fingerlings and 540 subcatchables; Appendix B). Fingerling stockings were switched from odd to even years in 2003 to consolidate and minimize transportation costs. The fishery does not appear in the Statewide Harvest Survey because there were too few respondents to provide reliable harvest estimates.

Population sampling was conducted June 5–7, 2006 and 31 rainbow trout (Figure 7), 1 coho salmon (186 mm), and 1 lake trout (250 mm) were captured. Visual comparison of the observed LFD with management and predicted population structures indicated the distribution of rainbow trout lengths was similar to expected lengths. The fingerling and subcatchable stockings in 2004 made it difficult to distinguish between age cohorts due to extensive overlap of their LFDs. The absence of older age cohorts was the result of not stocking the lake in 2002 or 2003.

The differences between the observed population structure and management and predicted mean lengths for size category ≥ 250 mm were not statistically significant (Table **7**). All other differences were statistically significant for both relative abundances and mean lengths. Management and predicted criteria were met for mean lengths for size categories < 250 mm and ≥ 250 mm but not for relative abundance. Tests were not conducted for age cohorts.

The expected population abundance in 2006 was about 124 rainbow trout age-2 and older based on the stocking history and the predicted population model. The number of fish captured during this study also indicated the population abundance was small. The management population model calculated a biennial stocking scheme of 2,000 fingerling rainbow trout would likely provide fewer than 100 rainbow trout age-2 and older and less than 50 rainbow trout ≥ 250 mm, annually. The population abundance could be increased by stocking rainbow trout every year. Possible downsides for this action will be increased cost of stocking the fish and lower growth rates that will provide a less attractive fishery.

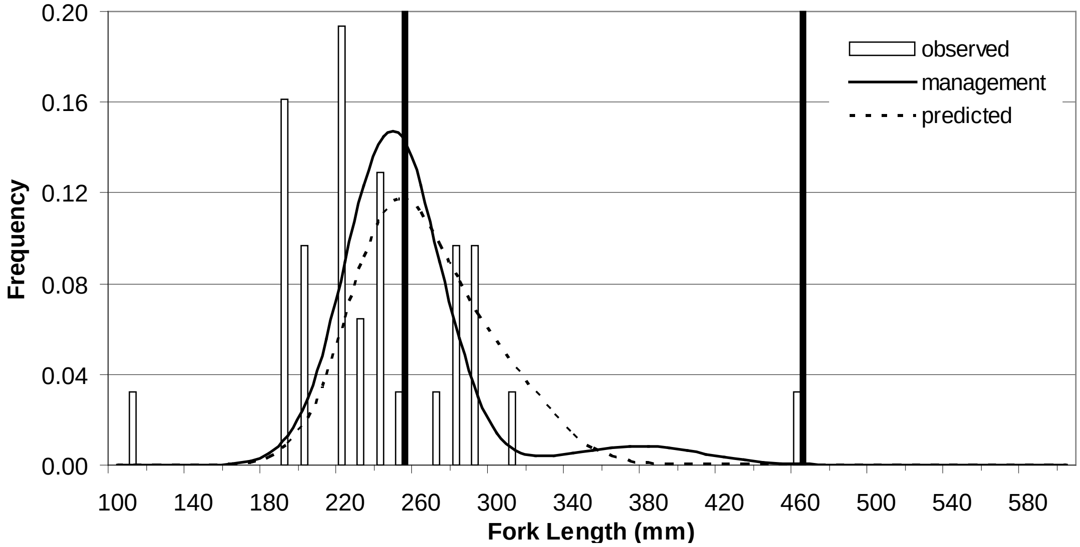

Figure 7.–Coal Mine #5 Lake: observed rainbow trout length frequency distribution compared to management and predicted criteria, (n = 31).

Table 7.–Coal Mine #5 Lake: test results by length category.

	Relative Abundance (χ^2 test)		**Mean Length** (t test)	
	<250 mm	≥250 mm	<250 mm	≥250 mm
Observed	21	10	205 mm	297 mm
	(0.68[a])	(0.32[a])	(6.49[b])	(18.02[b])
Management Criteria	14	17	225 mm	280 mm
	(0.46[a])	(0.54[a])		
Test Stat		5.90	-3.08	0.94
DF		1	20	9
P Value		0.015	0.006	0.370
Predicted Criteria	11	20	225 mm	282 mm
	(0.34[a])	(0.66[a])		
Test Stat		15.7	-3.08	0.83
DF		1	20	9
P Value		0.0001	0.006	0.43

[a] Proportion of catch.
[b] Standard error.

Coal Mine # 5 Lake: population length-age structure

	Length Category		Age Cohort			
	< 250 mm	≥ 250 mm	1	2	3	4
Mean Length(FL)	225 mm	280mm	125mm	245mm	320mm	374mm
Relative Abundance	0.46	0.54	0.00	0.93	0.00	0.07

Notes: Values in the table were calculated for even years. Values for odd years will be different. Mean lengths for age cohorts were calculated for spring.

Recommended Actions

- Biennial stockings of 2,000 fingerling rainbow trout (2 g) by mid-June.
- Evaluate the cost and benefit of other stocking schemes to determine if the population abundance and length structure can be improved to provide a greater number of fish ≥ 250 mm.
- Assess the population structure in 2010 or 2011 to determine if the biennial stocking scheme, or an alternative scheme, is meeting population structure objectives for regional management.

Last Lake

Last Lake is located along the Coal Mine Road 35 km South of Delta Junction at Kilometer 390.4 (Mile 242.4) of the Richardson Highway (Upper Tanana Management Area; Figure 3). The lake covers 2 surface ha and was first stocked with rainbow trout fingerlings in 1992. Recently, rainbow trout were stocked as fingerlings in 2002, 2004, and 2006. About 1,000 fingerlings were stocked each year along with 324 catchables in 2004 (Appendix B). The fishery does not appear in the Statewide Harvest Survey because there were too few respondents to provide reliable harvest estimates.

Population sampling was conducted June 5–6, 2006 and no fish were captured. The lake is 5 m deep and may have winterkilled in the past based on reports from anglers and fishery biologists.

Recommended Actions

- Annual stockings of 300 catchable rainbow trout (120 g) by mid-June to provide a summer fishery.
- Stockings should be stopped if catchables are not available or stocking costs are too high.
- Survey lake to obtain data to generate a bathymetric map and determine aquatic vegetative coverage.
- Determine water depth that will sustain fish all year.

Firebreak Lake

Firebreak Lake is located 39 km west of Nenana (Lower Tanana Management Area; Figure 2). Access is by aircraft or snow machine. The lake covers 40 surface ha and was first stocked with rainbow trout fingerlings in 1988. Recently, rainbow trout were stocked as fingerlings in 2001, 2003, and 2005. About 10,000 fingerlings were stocked each year (Appendix B). The fishery does not appear in the Statewide Harvest Survey because there were too few respondents to provide reliable harvest estimates.

Population sampling was conducted September 12–14, 2006 and no fish were captured. Anglers have reported the lake water level has been dropping during the last five years. Maximum depth was 2 m and along with other factors may have contributed to winterkill.

Recommended Actions

- Stop stocking the lake until water depth is adequate to sustain fish all year.
- Survey lake to obtain data to generate a bathymetric map and determine aquatic vegetative coverage.
- Determine water depth that will sustain fish all year.

Jan Lake

Jan Lake is 0.4 km south of the Alaska Highway at Kilometer 2,179.5 (Mile 1,353.5) (Upper Tanana Management Area; Figure 3). The lake covers 18 surface ha and was first stocked with rainbow trout fingerlings in 1971. Rainbow trout captured during this experiment were stocked as fingerlings in 2004 (Appendix B). Fingerling stockings were switched from odd to even years in 2003 to minimize the costs associated with aerial and ground transport activities. The lake was not stocked with rainbow trout fingerlings in 2002 or 2003. Coho salmon fingerlings were also stocked in the lake. The fishery does not appear in the Statewide Harvest Survey because there were too few respondents to provide reliable harvest estimates.

Population sampling was conducted September 19–21, 2006 and 98 rainbow trout (Figure 8) and 458 coho salmon (Figure 9) were captured. Visual comparison of LFDs showed the actual rainbow trout lengths were smaller compared to those based on management and predicted population structures (Figure 8). The observed mean lengths for size category < 250 mm were not statistically different from either management or predicted mean lengths (Table 8). All other differences for relative abundances and mean lengths were statistically significant. Management and predicted criteria were met for mean lengths for size categories < 250 mm and ≥ 250 mm but not for relative abundance. Only one age cohort was present; therefore, no tests were conducted for age cohorts.

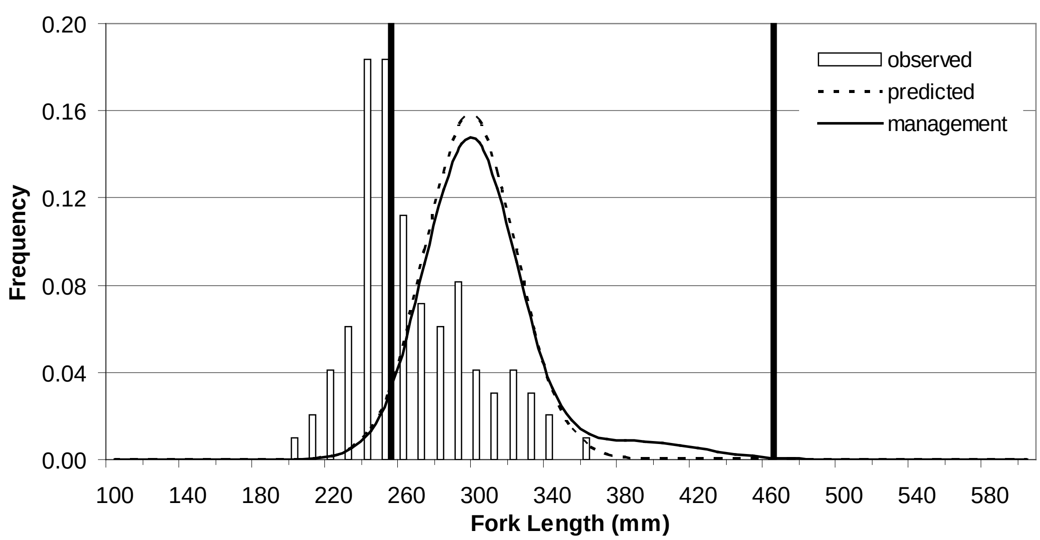

Figure 8.–Jan Lake: observed rainbow trout length frequency distribution compared to management and predicted criteria, (n = 98).

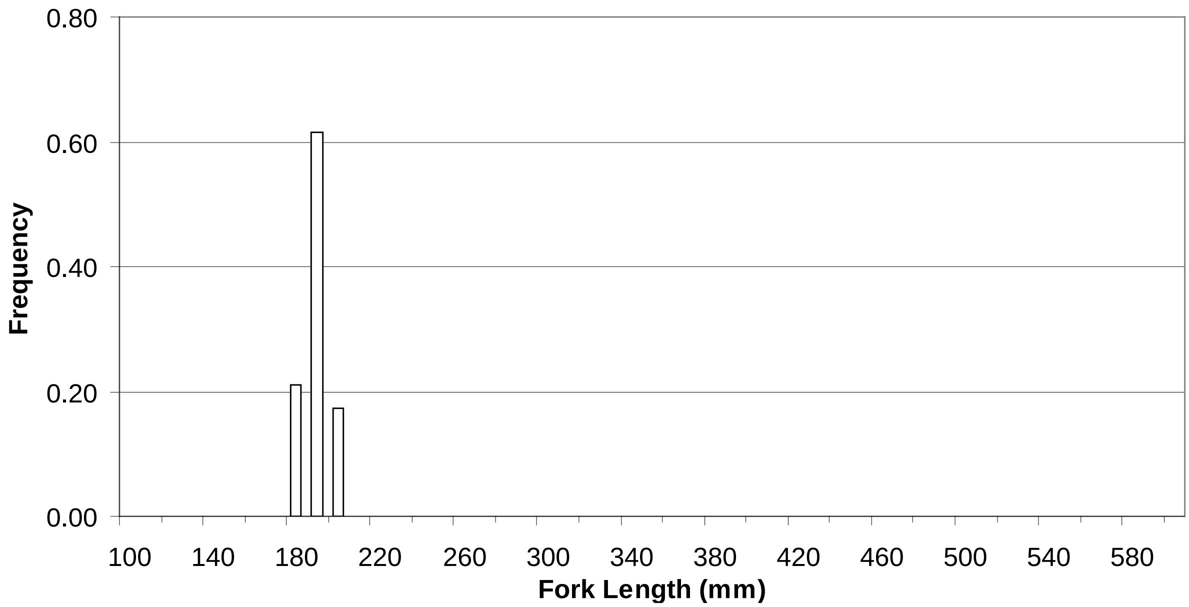

Figure 9.–Jan Lake: observed coho salmon length frequency distribution compared to management and predicted criteria, (n = 138).

Table 8.–Jan Lake: test results by length category.

	Relative Abundance (χ^2 test)		Mean Length (t test)	
	<250 mm	≥250 mm	<250 mm	≥250 mm
Observed	49 (0.50[a])	49 (0.50[a])	233 mm (1.75[b])	285 mm (3.77[b])
Management Criteria	2 (0.02[a])	96 (0.98[a])	235 mm	303 mm
Test Stat		1,152	-0.92	-4.73
DF		1	48	48
P Value		<0.0001	0.36	<0.0001
Predicted Criteria	2 (0.02[a])	96 (0.98[a])	235 mm	301 mm
Test Stat		1,152	-0.92	-4.20
DF		1	48	48
P Value		<0.0001	0.361	<0.0001

[a] Proportion of catch.
[b] Standard error.

Field biologists noted that while rainbow trout and coho salmon were abundant, the visual comparison of body volume to length was less than that for other populations. This was likely the result of stocking more coho salmon than usual in 2005 (Appendix B). The combined populations of rainbow trout and coho salmon likely exceeded the number of fish that could be adequately supported by lake resources. This situation could also reduce growth rates during 2006 and 2007.

Although the criteria for mean length were met, managers have inferred from field observations that the abundance of fish was excessive. Because the fish were thin most anglers would not find the fishery attractive. It is likely that the criteria for length at age-3 will not be achieved if more fish are stocked in 2007. A possible action is to not stock coho salmon in 2007 and stock half the usual number of rainbow trout in 2008. This action will reduce the number of fish in the lake with the anticipated result of improving the growth rate. The goal is to maintain a population length/age structure that is attractive to anglers.

Jan Lake: management population length-age structure.

	Length Category		Age Cohort			
	< 250 mm	≥ 250 mm	1	2	3	4
Mean Length(FL)	235 mm	303mm	220mm	295mm	345mm	385mm
Relative Abundance	0.02	0.98	0.00	0.93	0.00	0.07

Notes: Values in the table were calculated for even years. Values for odd years will be different. Mean lengths for age cohorts were calculated for fall.

Recommended Actions

- For 2008 reduce the biennial stockings of 8,000 fingerling rainbow trout to 4,000 (2 g) by mid-June. Return to normal stocking numbers in 2010.
- For 2007 don't stock coho salmon. In 2009, return to biennial stockings of 4,500 fingerling coho salmon (4 g) by August.
- Assess the population structure in 2010 or 2011 to determine if the biennial stocking scheme is meeting population structure objectives for regional management.

Lisa Lake

Lisa Lake is 1.1 km south of the Alaska Highway at Kilometer 2,223.8 (Mile 1,381) (Upper Tanana Management Area; Figure 3). The lake covers 20 surface ha and was first stocked with rainbow trout fingerlings in 1963. Rainbow trout captured during this experiment were stocked as fingerlings in 2001, 2003, and 2004. Each year, 9,000 to 10,000 fish were stocked (Appendix B). Fingerling stockings were switched from odd to even years in 2004 to minimize the costs associated with aerial and ground transport activities. The consecutive stockings in 2003 and 2004 made it difficult to distinguish between age cohorts (Figure 10). The fishery does not appear in the Statewide Harvest Survey because there were too few respondents to provide reliable harvest estimates.

Population sampling was conducted September 18–October 6, 2006 and 290 unique rainbow trout were captured. Visual comparison of LFDs showed obvious similarities in mode location and amplitude between the actual population structure and those based on management and predicted criteria (Figure 10). Fewer large fish were present in the sample than predicted. All differences between the observed population structure and management and predicted population structures were statistically significant (Table 9). However, the rainbow trout population met all management and predicted criteria for relative abundance and mean length. Age cohorts could not be reliably identified and no statistical tests were performed.

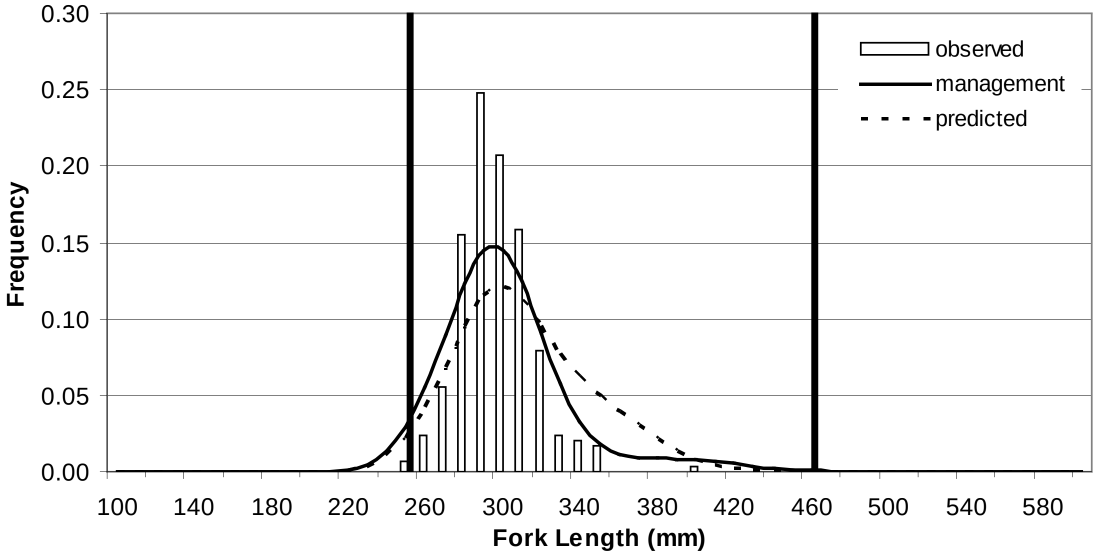

Figure 10.–Lisa Lake: observed rainbow trout length frequency distribution compared to management and predicted criteria, (n = 290).

Table 9.–Lisa Lake: test results by length category.

	Relative Abundance (χ^2 test)		**Mean Length** (t test)	
	<250 mm	≥250 mm	<250 mm	≥250 mm
Observed	2	288	245 mm	293 mm
	(0.01[a])	(0.99[a])	(1.00[b])	(1.09[b])
Management Criteria	7	338	235 mm	303 mm
	(0.02[a])	(0.98[a])		
Test Stat		2.54	10.00	-8.84
DF		1	1	287
P Value		0.11	0.064	<0.0001
Predicted Criteria	7	338	235 mm	312 mm
	(0.02[a])	(0.98[a])		
Test Stat		2.54	10.00	-17.10
DF		1	1	287
P Value		0.11	0.064	<0.0001

[a] Proportion of catch.

[b] Standard error.

A consistent biennial stocking schedule would likely produce a population structure that more resembled that calculated for management criteria.

Lisa Lake management population length-age structure

	Length Category		Age Cohort			
	< 250 mm	≥ 250 mm	1	2	3	4
Mean Length(FL)	235 mm	303mm	220mm	295mm	345mm	385mm
Relative Abundance	0.02	0.98	0.00	0.93	0.00	0.07

Notes: Values in the table were calculated for even years. Values for odd years will be different. Mean lengths for age cohorts were calculated for fall.

Recommended Actions

- Biennial stockings of 10,000 fingerling rainbow trout (2 g) by mid-June.
- Assess the population structure in 2010 or 2011 to determine if the biennial stocking scheme is meeting population structure objectives for regional management.

Tolsona Mt. Lake

Tolsona Mt. Lake is on the north side of the Glenn Highway at Kilometer 274 (Mile 170) (Upper Copper/Upper Susitna Management Area; Figure 4). The lake covers 30 surface ha and was first stocked with rainbow trout fingerlings in 1982. Rainbow trout captured during this experiment were stocked as fingerlings in 2001 and 2004. About 15,000 fish were stocked each year (Appendix B). Fingerling stockings were switched from odd to even years in 2003 to minimize the costs associated with aerial and ground transport activities.

Population sampling was conducted September 27–29, 2006 and 72 rainbow trout (Figure 11) were captured. Visual comparison of LFDs identified no obvious mode for the observed population structure. However, the LFDs for management and predicted population structures were centered within the range of observed fish lengths. All differences between the observed population structure and management and predicted population structures were statistically significant (Table 10). However, the rainbow trout population met all management and predicted criteria for mean length. Age cohorts could not be reliably identified and no statistical tests were performed. The fishery does not appear in the Statewide Harvest Survey because there were too few respondents to provide reliable harvest estimates.

The sample was likely comprised of age-2 fish only and it was likely that the small sample size was insufficient to distinguish the mode. Age-5 fish probably were not present in the sample because they would represent only a very small component of the population. A model predicted 600 age-2 and 5 age-5 fish in the population.

A consistent biennial stocking schedule would likely produce a population structure that more closely resembled that calculated for management criteria.

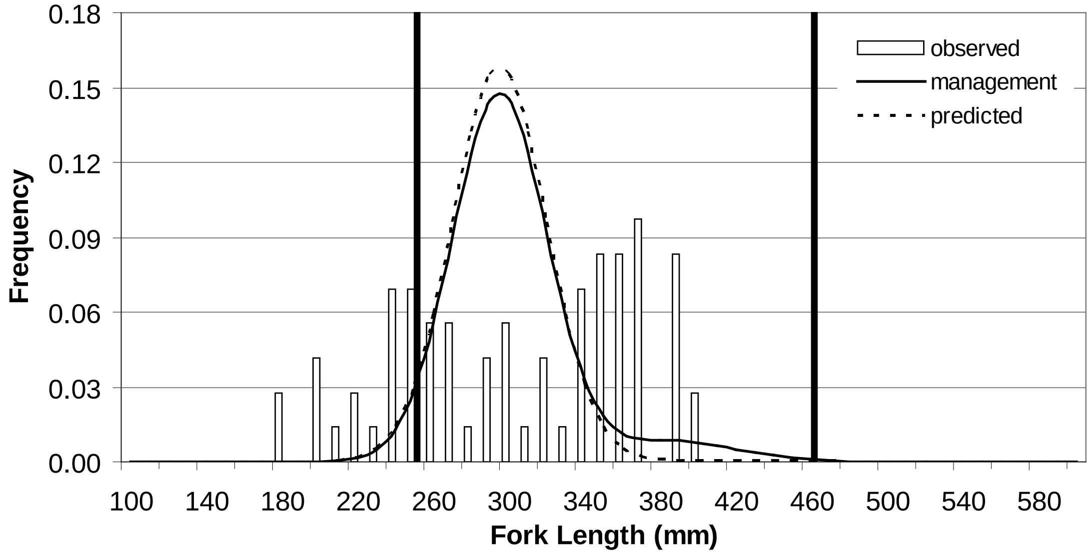

Figure 11.–Tolsona Mt. Lake: observed rainbow trout length frequency distribution compared to management and predicted criteria, (n = 72).

Table 10.–Tolsona Mt. Lake: test results by length category.

	Relative Abundance (χ^2 test)		**Mean Length** (t test)	
	<250 mm	≥250 mm	<250 mm	≥250 mm
Observed	19 (0.26[a])	53 (0.74[a])	221 mm (5.18[b])	332 mm (5.89[b])
Management Criteria	1 (0.02[a])	71 (0.98[a])	235 mm	203 mm
Test Stat		218.5	-2.75	4.91
DF		1	18	52
P Value		<0.0001	0.013	<0.0001
Predicted Criteria	1 (0.02[a])	71 (0.98[a])	235 mm	297 mm
Test Stat		218.5	-2.75	5.93
DF		1	18	52
P Value		<0.0001	0.013	<0.0001

[a] Proportion of catch.
[b] Standard error.

Tolsona Lake: management population length-age structure

	Length Category		Age Cohort			
	< 250 mm	≥ 250 mm	1	2	3	4
Mean Length(FL)	235 mm	303mm	220mm	295mm	345mm	385mm
Relative Abundance	0.02	0.98	0.00	0.93	0.00	0.07

Notes: Values in the table were calculated for even years. Values for odd years will be different. Mean lengths for age cohorts were calculated for fall.

Recommended Actions

- Biennial stockings of 15,000 fingerling rainbow trout (2 g) by mid-June.
- Assess the population structure in 2010 or 2011 to determine if the biennial stocking scheme is meeting population structure objectives for regional management.

Triangle Lake

Triangle Lake is located 58 km west of Nenana (Lower Tanana Management Area; Figure 3). Access is by aircraft or snow machine. The lake covers 43 surface ha and was first stocked with rainbow trout fingerlings in 1988. Rainbow trout captured during this experiment were stocked as fingerlings in 2001, 2003, and 2005. About 10,000 fingerlings were stocked each year (Appendix B). The fishery does not appear in the Statewide Harvest Survey because there were too few respondents to provide reliable harvest estimates.

Population sampling was conducted September 20–22, 2006 and 15 rainbow trout (Figure 12) were captured. Visual comparison of LFDs found obvious differences in mode locations between observed population structures and those based on management and predicted population structures (Figure 12). The observed fish lengths were larger than expected. The differences between the observed population structure and management and predicted population structures for mean length ≥ 250 mm were not statistically significant (Table 11). Comparisons were not made for size category < 250 mm because too few fish were captured. All other differences including relative abundance were statistically significant (Tables 11 and 12). The rainbow trout population met all management and predicted criteria for mean length for size and age categories.

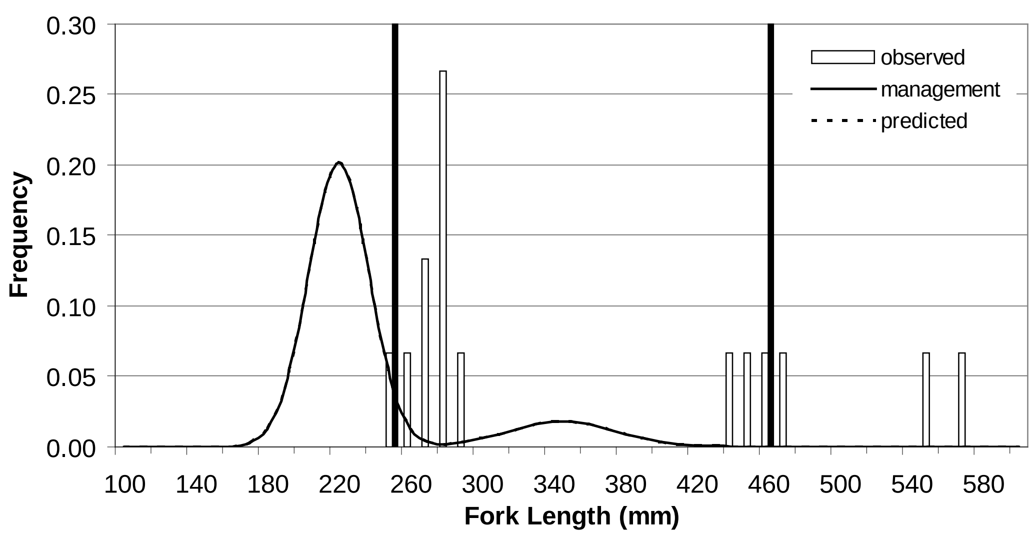

Figure 12.–Triangle Lake: observed rainbow trout length frequency distribution compared to management and predicted criteria, (n = 15).

Table 11.–Triangle Lake: test results by length category.

	Relative Abundance (χ^2 test)		Mean Length (t test)	
	<250 mm	≥250 mm	<250 mm	≥250 mm
Observed	1 (0.07[a])	14 (0.93[a])	241 mm (---[b])	264 mm (31.04[b])
Management Criteria	12 (0.80[a])	3 (0.20[a])	218 mm	319 mm
Test Stat		50.4	---	1.44
DF		1	0	13
P Value		<0.0001	---	0.173
Predicted Criteria	1 (0.80[a])	14 (0.20[a])	218 mm	319 mm
Test Stat		50.4	---	1.44
DF		1	0	13
P Value		<0.0001	---	0.173

[a] Proportion of catch.
[b] Standard error.

Table 12.–Triangle Lake: test results by age cohort.

	Relative Abundance (χ2 test)			Mean Length (t test)		
	age-1	age-2	age-3	age-1	age-2	age-3
Observed	9 (0.60[a])	0	6 (0.40[a])	268 mm (4.87[b])	0	486 mm (23.5[b])
Management Criteria	13 (0.86[a])	0	2 (0.14[a])	220 mm	0	346 mm
Test Stat			8.42	9.86		5.95
DF			1	8		5
P Value			0.0037	<0.0001		0.0019
Predicted Criteria	13 (0.86[a])	0	2 (0.14[a])	220 mm	0	346 mm
Test Stat			8.42	9.86		5.95
DF			1	8		5
P Value			0.0037	<0.0001		0.0019

[a] Proportion of catch.
[b] Standard error.

A population model predicted an abundance of 1,000 age-1, 160 age-3, and 3 age-5 fish. The small sample size suggested that the actual abundance may be less. Inferences about the population structure may not be reliable due to the small sample size.

Triangle Lake management population length-age structure

	Length Category		Age Cohort			
	< 250 mm	≥ 250 mm	1	2	3	4
Mean Length(FL)	218 mm	319mm	220mm	295mm	345mm	385mm
Relative Abundance	0.80	0.20	0.86	0.00	0.14	0.00

Notes: Values in the table were calculated for even years. Values for odd years will be different. Mean lengths for age cohorts were calculated for fall.

A possible reason for the small sample size was the result of low abundance due to a larger than expected portion of the population being harvested. The harvest level was unknown for Triangle Lake. ADF&G had assumed that harvest was low because the lake was remote. The number of anglers that visit the lake may have increased because large fish (≥ 460 mm) were present. Transporters fly anglers to other lakes in this area and more anglers could be fishing at Triangle Lake.

Recommended Actions

- Biennial stockings of 10,000 fingerling rainbow trout (2 g) by mid-June.
- Question transporters, guides, and pilots about the Triangle Lake fishery to determine a crude estimate of angler use and harvest.
- Assess the population structure in 2010 or 2011 to determine if the biennial stocking scheme is meeting population structure objectives for regional management.

West Iksgiza Lake

West Iksgiza Lake is located 61 km west of Nenana (Lower Tanana Management Area; Figure 2). Access is by aircraft or snow machine. The lake covers 33 surface ha and was first stocked with rainbow trout fingerlings in 2004. Rainbow trout captured during this experiment were stocked as fingerlings in 2004 and 2005 (Appendix B). The fishery does not appear in the Statewide Harvest Survey because the fishery was new and there were too few respondents to provide reliable harvest estimates.

Population sampling was conducted September 22–23, 2006 and 150 rainbow trout were captured (Figure 13). Visual comparison of LFDs found obvious similarities in mode amplitudes but differences in mode locations between actual population structures and those based on management and predicted criteria (Figure 13). The observed fish lengths were larger than expected. The differences between the observed population structure and predicted population structures were not statistically significant for mean length ≥ 250 mm (Table 13). All other differences for relative abundances, mean lengths and age cohorts were statistically significant (Tables 13 and 14). However, the rainbow trout population met the management and predicted criteria for mean length for size category and age cohort. Management and predicted criteria were not met for relative abundance by size category or age cohort. The fishery is new and it does not appear in the Statewide Harvest Survey because there were too few respondents to provide reliable harvest estimates.

West Iksgiza Lake management population length-age structure

	Length Category		Age Cohort			
	< 250 mm	≥ 250 mm	1	2	3	4
Mean Length(FL)	218 mm	319mm	220mm	295mm	345mm	385mm
Relative Abundance	0.80	0.20	0.86	0.00	0.14	0.00

Notes: Values in the table were calculated for even years. Values for odd years will be different. Mean lengths for age cohorts were calculated for fall.

The shape of the actual population structure more resembled that of the management population structure than that of the predicted population structure. The location of the modes for the age-1 and age-2 fish resembled those expected for age-1 and age-3 fish. This may be the result of high growth rates that often occur when a lake is stocked for the first time. Usually, after the first or second stocking, growth rates decrease with subsequent stockings. This is a new fishery and, for now, is used only by a small number of anglers. In the next few years more anglers will learn about the large fish (≥ 460 mm) and the number of anglers who use the fishery and the number of fish harvested will likely increase. To maintain high growth rates the number of fish stocked in the future should be reduced. The West Iksgiza Lake fishery is managed under "regional" management objectives. The stocking strategy should be manipulated to produce a population structure that provides for a reasonable expectation of catching the daily bag limit and not the production of large fish. To meet this objective in the future may require maintaining or increasing the number of fish that are stocked which will likely result in lower growth rates and fewer large fish in the population.

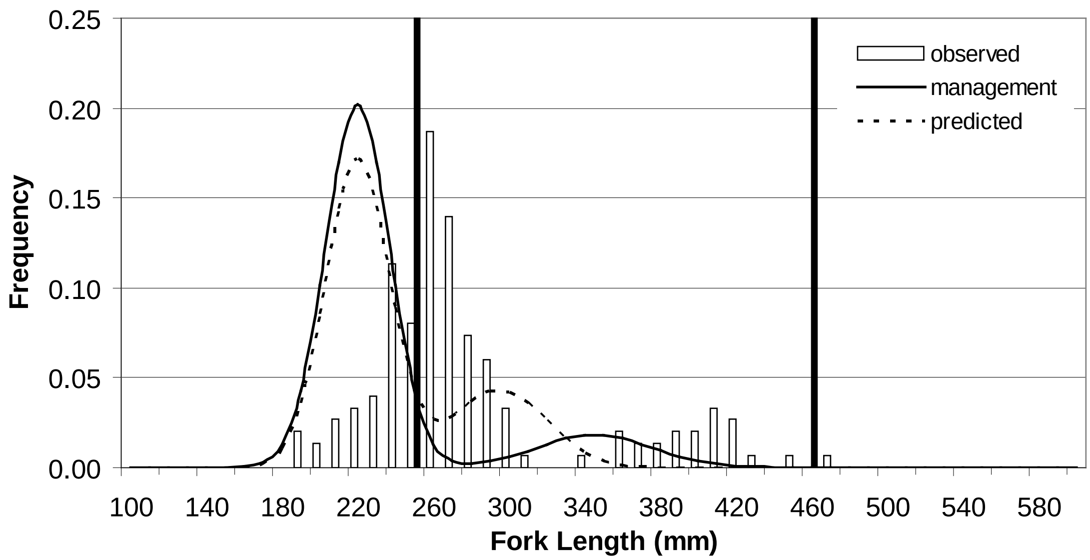

Figure 13.–West Iksgiza Lake: observed rainbow trout length frequency distribution compared to management and predicted criteria, (n = 150).

Table 13.–West Iksgiza Lake: test results by length category.

	Relative Abundance (χ^2 test)		Mean Length (t test)	
	<250 mm	≥250 mm	<250 mm	≥250 mm
Observed	47	103	227 mm	300 mm
	(0.31[a])	(0.69[a])	(2.52[b])	(5.75[b])
Management Criteria	120	30	218 mm	319 mm
	(0.80[a])	(0.20[a])		
Test Stat		222	3.60	-3.38
DF		1	46	102
P Value		<0.0001	0.0008	0.0010
Predicted Criteria	104	47	218 mm	290 mm
	(0.69[a])	(0.31[a])		
Test Stat		99.5	-3.608	1.66
DF		1	46	102
P Value		<0.0001	0.0008	0.1005

[a] Proportion of catch.
[b] Standard error.

Table 14.–West Iksgiza Lake: test results by age cohort.

	Relative Abundance (χ2 test)			Mean Length (t test)		
	age-1	age-2	age-3	age-1	age-2	age-3
Observed	124	26	0	252 mm	394 mm	0
	(0.83[a])	(0.17[a])		(2.22[b])	(5.76[b])	
Management Criteria	129		21	220 mm	-	345
	(0.86[a])	0	(0.14[a])			
Test Stat			No Test	14.4		No test
DF				123		
P Value				<0.0001		
Predicted Criteria	110	41	0	220 mm	295 mm	
	(0.73[a])	(0.27[a])				
Test Stat	1,605	7.11		22.4	24.9	
DF	1	1		123	25	
P Value	<0.24	0.0077		<0.0001	<0.0001	

[a] Proportion of catch.
[b] Standard error.

Recommended Action

- Biennial stockings of 10,000 fingerling rainbow trout (2 g) by mid-June.
- Assess the population structure in 2010 or 2011 to determine if the biennial stocking scheme is meeting population structure objectives for regional management.
- Monitor the number of anglers who use the fishery and the number of fish that are harvested through interviews with cabin owners and anglers who use the fishery.

CONSERVATIVE MANAGEMENT LAKES

Dune Lake

Dune Lake is located 40 km south west of Nenana (Lower Tanana Management Area; Figure 2). Access is by aircraft or snow machine. The lake covers 72 surface ha and was first stocked with rainbow trout fingerlings in 1984. The lake was also stocked with coho salmon and Arctic grayling. Rainbow trout captured during this experiment were stocked as fingerlings in 2003 and 2005 (Appendix B). The fishery occasionally appeared in the Statewide Harvest Survey when there were sufficient numbers of respondents to provide reliable harvest estimates.

Population sampling was conducted March 30 through June 2, 2006 and 569 rainbow trout and 399 Arctic grayling were captured (Figures 14 and 15). Visual comparison of LFDs for rainbow trout found obvious differences in mode amplitudes and locations between the actual population structure and those based on management and predicted criteria (Figure 14). Fewer age-1 rainbow trout were captured than expected and lengths were much larger than expected for the age-3 cohort. The differences between the observed population structure and the management and predicted population structures were not statistically significant for mean length ≥ 460 mm (Table 15). All other differences for relative abundances, mean lengths and age cohorts were statistically significant (Tables 15 and 16). However, the rainbow trout population met the management and predicted criteria for mean length for size category and age cohort. Management and predicted criteria were not met for relative abundance by size category or age cohort.

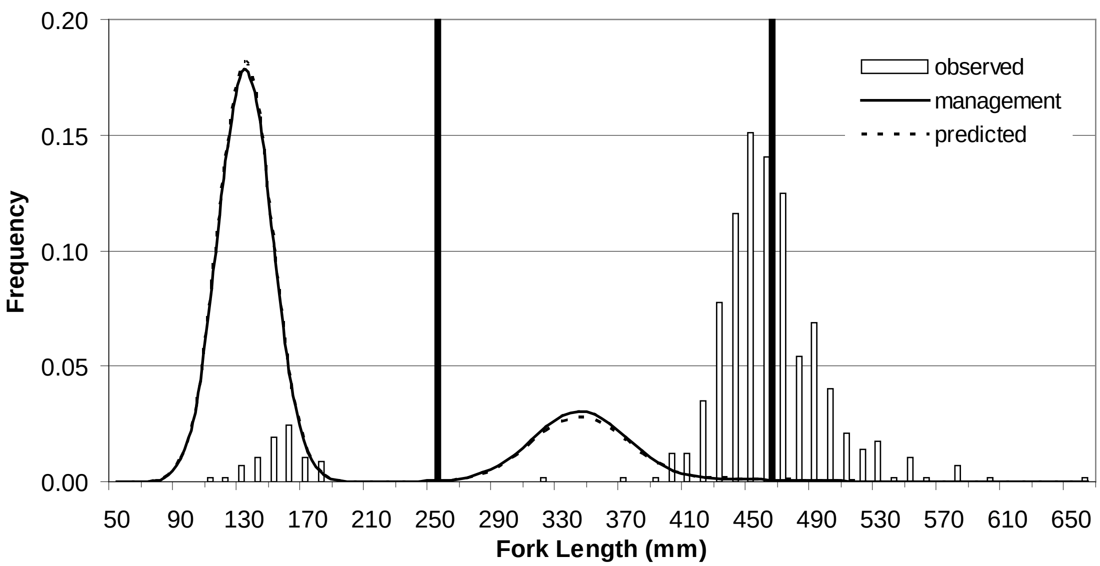

Figure 14.–Dune Lake: observed rainbow trout length frequency distribution compared to management and predicted criteria (n = 569).

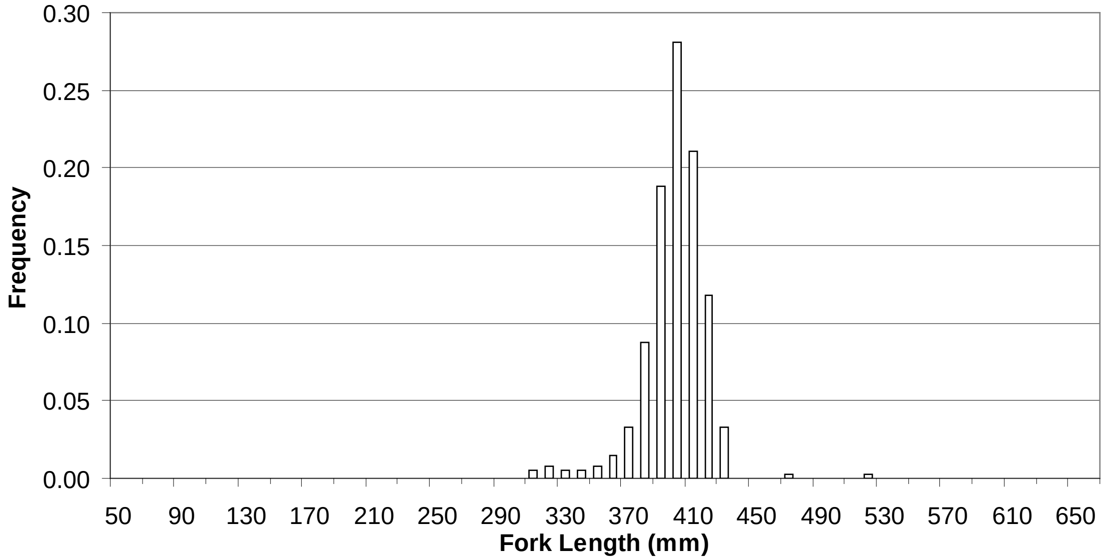

Figure 15.–Dune Lake: observed Arctic grayling length frequency distribution, (n = 399).

Table 15.–Dune Lake: test results by length category.

	Relative Abundance ($\chi 2$ test)				**Mean Length** (t test)			
	<250 mm	≥250 mm	<460 mm	≥460 mm	<250 mm	≥250 mm	<460 mm	≥460 mm
Observed	48 (0.08[a])	521 (0.92[a])	344 (0.60[a])	225 (0.40[a])	150 mm (2.26[b])	459 mm (1.44[b])	398 mm (5.46[b])	486 1.91
Management Criteria	432 (0.76[a])	137 (0.24[a])	569 (1.0[a])	0 (0[a])	131 mm	345 mm	181 mm	484 mm
Test Stat		1,424		---	8.42	79.1	39.7	1.05
DF		1			47	520	343	224
P Value		<0.0001			<0.0001	<0.0001	<0.0001	0.296
Predicted Criteria	444 (0.08[a])	125 (0.92[a])	563 (0.60[a])	6 (0.40[a])	131 mm	347 mm	178 mm	484 mm
Test Stat		1,605		8,538	8.42	77.7	40.3	1.05
DF		1		1	47	520	343	224
P Value		<0.0001		<0.0001	<0.0001	<0.0001	<0.0001	0.296

[a] Proportion of catch.

[b] Standard error.

Table 16.–Dune Lake: test results by age cohort.

	Relative Abundance ($\chi2$ test)			**Mean Length** (t test)		
	age-1	age-2	age-3+[a]	age-1	age-2	age-3+[a]
Observed	48 (0.08[b])	0	521 (0.92[b])	150 mm (2.26[c])	0	459 mm (1.44[c])
Management Criteria	432 (0.76[b])	0	137[c] (0.24[b])	131 mm	0	345 mm
Test Stat			1,424	8.42		79.1
DF			1	47		520
P Value			<0.0001	<0.0001		<0.0001
Predicted Criteria	444 (0.78[b])	0	125 (0.22[b])	131 mm	0	347 mm
Test Stat			1,605	8.42		77.7
DF			1	47		520
P Value			<0.0001	<0.0001		<0.0001

[a] Age-3 and age -4 cohorts could not be distinguished and were combined for data analysis.

[b] Proportion of catch.

[c] Standard error.

Dune Lake management population length-age structure(< 250 mm and ≥ 250 mm)

	Length Category		Age Cohort			
	< 250 mm	≥ 250 mm	1	2	3	4
Mean Length(FL)	131 mm	345mm	131mm	261mm	341mm	399mm
Relative Abundance	0.76	0.24	0.76	0.00	0.24	0.00

Notes: Values in the table were calculated for even years. Values for odd years will be different. Mean lengths for age cohorts were calculated for spring.

Dune Lake management population length-age structure (< 460 mm and ≥ 460 mm)

	Length Category		Age Cohort			
	< 460 mm	≥ 460 mm	1	2	3	4
Mean Length(FL)	181 mm	484mm	131mm	261mm	341mm	399mm
Relative Abundance	0.99	0.01	0.76	0.00	0.24	0.00

Notes: Values in the table were calculated for even years. Values for odd years will be different. Mean lengths for age cohorts were calculated for spring.

The low relative abundance of age-1 rainbow trout in the sample may indicate low survival rates for the age-1 cohort. While unusual, a similar situation was observed for the Dune Lake rainbow trout population in 2000 (Skaugstad and Fish 2002). The authors speculated that the low survival rate for the age-1 cohort was likely the result of predation from larger coho salmon and rainbow trout or injuries resulting from the aerial transport. The solution was to stock rainbow trout fingerlings again in 2001. Rainbow trout fingerlings are scheduled for stocking in 2007.

The survival rate of rainbow trout from the 2003 stocking (age-3 in 2006) was better than expected. A population model predicted only 360 age-3 rainbow trout compared to 569 that were captured during sampling. The study in 2000 estimated 472 (SE = 87) rainbow trout > 300 mm. Higher survival rates for the age-3 cohort in 2006 may be the result of reducing the daily bag limit in 2005 from 10 rainbow trout, 10 coho salmon, and 5 Arctic grayling to 5 fish all species combined.

Recommended Actions

- Biennial odd year stockings of 10,000 fingerling rainbow trout (2 g) by-mid June.
- Biennial even year stockings of 9,000 fingerling coho salmon (2 g) and 10,000 fingerling Arctic grayling (2 g) by mid-August.
- Assess the population structure in 2010 or 2011 to determine if the biennial stocking scheme is meeting population structure objectives for conservative management.

TWO-SAMPLE FISH POPULATION MONITORING

A two-sample mark-recapture experiment was performed on the rainbow trout population in Lisa Lake, one of the 10 populations sampled during the 2006 field season. The management objectives for this mark-recapture experiment were to estimate the abundance of stocked rainbow trout and to evaluate the potential for size bias sampling when sampling was conducted as a one-sample event. We prefer to use one-sample events to estimate population structures for comparison with fishery management objectives. But, potential size bias sampling cannot be evaluated from data collected during single-sample events. Size bias sampling can be detected with the Kolmogorov-Smirnov (K-S) test (Conover 1980) by comparing the size distributions of fish collected during experiments using multiple-sample events. However, only extreme size bias is detectable with power > 50% during two-sample mark-recapture experiments that are conducted on small populations where less than 50% of the population was sampled over the entire experiment. Most sampling projects that we conduct capture less than 50% of the population. While this experiment will not reliably detect subtle differences in capture probabilities, it will detect size bias to the extent it is detectable with the best currently applied experimental designs.

Limited resources and a short sampling season in Interior Alaska require short, one-sample events to maximize the number of populations that can be sampled. Effective gear and efficient sampling techniques were necessary to complete sampling activities in a timely manner. One-sample events were used to collect length data to generate length frequency distributions. Biologists wanted to determine if the data collected using one-sample events adequately represent the actual population structures.

During previous experiments that used one- and two-sample events, biologists found that fyke nets were highly effective at capturing rainbow trout raging in size from approximately 50 mm to 500 mm FL. Fyke nets, however, were most effective when fished nearshore in water < 2 m deep. To ensure that no portion of a population was missed, tangle nets, fyke nets, and/or baited hoop traps were also fished offshore in water ≥ 2 m. Capture rates in offshore areas were typically low when water temperature was < 18 C 0.5 m beneath the surface. During a two-event mark-recapture experiment conducted at Quartz Lake, Fish and Skaugstad (2004) reported that less than 1% of rainbow trout captured in early June were captured in offshore fyke nets, hoop nets, or tangle nets.

Recent sampling activities were conducted when water temperatures were < 18°C to minimize temperature induced stress and to avoid variable capture probabilities. Increasing water temperature may trigger changes in fish distribution and/or activity, resulting in varying capture probabilities. Previous studies evaluating the movement, temperature preference, and depth distribution of rainbow trout in various lakes found that rainbow trout often move to deeper water seeking thermal refuge when water temperatures increase (James and Kelso 1995; Rowe 1984; Overholtz et al. 1977; Horak and Tanner 1964).

Based on local field experience, previous success of various capture methods, and observed and documented effects of temperature on fish distribution and activity, biologists deem the current techniques used for one-sample events were sufficient to adequately represent the true population structure. Also, low capture rates previously observed in offshore areas when water temperatures were low (< 18°C) suggest that near shore fyke nets alone may be sufficient to provide adequate data to estimate population structures.

OBJECTIVES

Research Objective 1: Estimate the abundance of all rainbow trout in Lisa Lake in September 2006 such that the estimate is within ±20% of the true value 95% of the time.

Research Objective 2: Detect size bias sampling as a function of differential age class vulnerability to sampling gear.

a. If probability of capture of age-2 fish is less than 50% of the probability of capture of age-3 fish during both events or one event, reject the null hypothesis of equal probability of capture with power > 65% using alpha (Type I error) of 0.20 for rejection criteria.

b. If probability of capture of age-3 fish is less than 50% of the probability of capture of age 2-fish during only one event (not both events), reject the null hypothesis of equal probability of capture with power > 50% using alpha (Type I error) of 0.20 for rejection criteria.

METHODS

The population abundance of rainbow trout in Lisa Lake was estimated using two-sample mark-recapture techniques for a closed population (Seber 1982). Rainbow trout were captured and marked from September 18 through 22, 2006 (Event 1). Fish were again captured from 2 through October 6, 2006 (Event 2) and examined for marks. Water temperature was measured 0.5 m below the surface each day at 1400 hours. Rainbow trout in Lisa Lake were stocked as fingerlings in 2001, 2003, and 2004 (Appendix C).

SAMPLING PROCEDURE

Lisa Lake was divided into two sampling areas, offshore (≥ 2 m deep, Area I) and nearshore (< 2 m deep, Area II; Figure 16). Each capture event was divided into four 24-hr sampling periods. Both fyke nets and tangle nets were used during every sampling period.

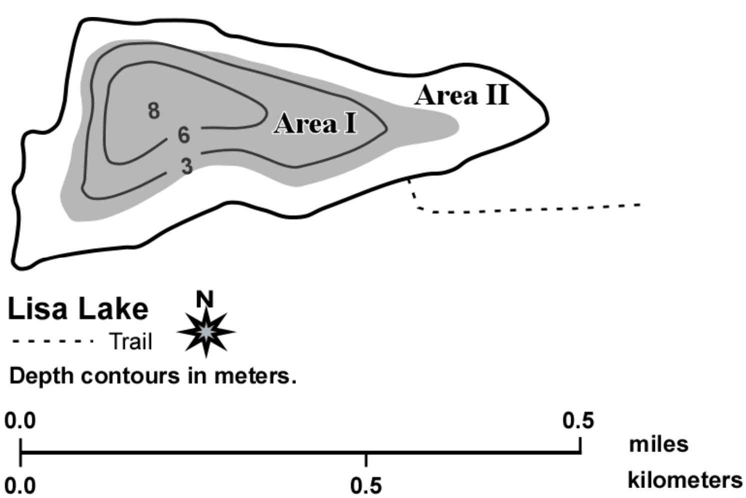

Figure 16.–Depths and sampling areas for Lisa Lake.

Fyke nets were set near shore (Area II) on the lake bottom in 1 to 2 m of water. The fyke net openings were 0.9 m^2, the body length from opening to cod end was about 5 m, hoop size was 0.9 m diameter, and mesh size was 9 mm^2. Wings were attached to each side of the open end and measured 7.5 m long by 1.2 m deep. The net body was positioned parallel to shore and the wings were set to form a "V". Each fyke net was pulled taut from the cod end and held in position with a weight.

A tangle net was set perpendicular to shore in water deeper than 2 meters (Area I). The tangle net measured 45 m (150 ft) long by 5.4 m (18 ft) deep and was made of 13 mm (½ in) bar fine thread monofilament. Mesh size was small to ensure that fish were captured by entanglement around the mouth and not by the gill covers. The lead line was weighted to overcome the buoyancy of the float line.

All fish captured during both events were measured to the nearest millimeter FL and examined for marks. Any unmarked fish was marked as specified in the marking schedule described below. To facilitate processing, the fish were partially anesthetized with a concentration of 100 mg/l spearmint oil in a water bath. After the fish were removed from the anesthesia they quickly recovered in a holding pen and swam away within several minutes. Any fish that showed signs of severe stress during the first event was released unmarked.

Fish captured during the first event were marked by removing a small portion of tissue from the upper (UC) or lower (LC) lobe of the caudal fin to identify sampling area. The fin clip removed approximately 5 mm of tissue from the tip of the fin lobe and produced a clean-cut edge that was readily distinguishable. A UC or LC mark identified a fish caught in a fyke net or tangle net, respectively. Fish captured multiple times in the first event were noted but were not given additional marks.

Fish captured during the second event were marked by completely excising the adipose (AD) fin. There was no differential marking between gear types and fish captured multiple times during the second event were not given additional marks.

Any fish that had either tip of the caudal fin removed during Event 1 was classified as "marked." Any fish captured during Event 1 with a caudal fin clip was classified as "captured more than once during the first event." Any fish captured during Event 2 with a caudal fin clip was classified as "recaptured" (captured in the first and second events) and the finclip was noted (UC or LC). Any fish captured in Event 2 with no mark was classified as "unmarked" (captured for the first time). Any fish captured during Event 2 that had both an adipose clip and caudal clip was classified as "recaptured more than once". Fish captured more than once during either event was noted but the additional captures were not used to estimate abundance.

Data were recorded on field data sheets specifying lake name, date, gear type, trap/net number, location marked on map, species, length, and type of mark (UC, LC, AD, or none). After field work was completed all data were transferred to Microsoft Excel spreadsheets, edited twice for errors, analyzed, and archived (Appendix B).

ASSUMPTIONS FOR A TWO-SAMPLE MARK-RECAPTURE EXPERIMENT

The assumptions necessary for accurate estimation of abundance in a closed population were as follows (Seber 1982):

1. the population was closed (no change in the number of rainbow trout in the population during the estimation experiment; (i.e., there was no immigration, emigration, births or deaths);
2. all rainbow trout had the same probability of capture in the marking event or in the recapture event, or marked and unmarked rainbow trout mixed completely between marking (Event 1) and recapture (Event 2);
3. marking rainbow trout did not affect their probability of capture in Event 2;
4. rainbow trout did not lose their mark between Event 1 and Event 2; and,
5. all marked rainbow trout were reported when recovered in Event 2.

For Assumption 1, no immigration or emigration was assured because the lake did not have inlets or outlets. No births occurred because rainbow trout do not reproduce in this lake. No "growth recruitment" (recruitment of fish to the minimum size catchable by gear type) occurred between events because all age-1 and older fish were susceptible to the capture gear types that were used during both sampling events. Some losses due to natural mortality and harvest likely occurred between sampling events; however marked and unmarked fish were expected to be subject to similar rates of loss. As such, the abundance estimate was germane to the time of Event 1. Any losses due to natural mortality or harvest between sampling events were likely minimal due to the short 7-day hiatus between capture events.

Assumption 2 was evaluated with respect to size selective sampling using diagnostic procedures described in Appendix C. The sampling design increased the likelihood that one or more of the conditions of Assumption 2 were met. Multiple gear types were used and various habitats were sampled to increase the chance that all fish had a similar probability of capture. Marked and unmarked fish mixed for seven days between sampling events and fish handled during both events were released at least 200 m from any capture gear.

To minimize the likelihood of higher mortality rates for marked fish several steps were taken in the experimental protocol to ensure Assumption 3 was met. All fish were carefully handled as they were processed, measured, and marked. Water temperature was monitored every day to avoid conditions that may induce stress or behavior changes. Tangle nets were checked frequently because they were more likely to injure fish. The seven-day hiatus between sampling events minimized the potential for capture-induced behavior of marked fish during Event 2.

Assumption 4 was assured because all fish were given a permanent secondary mark by completely excising the adipose fin. It was unlikely that a properly excised adipose fin would regenerate during the 3 week experiment. If the excised tip of a caudal fin grew back or was not identified as a mark then an excised adipose fin would identify a fish as having been captured in Event 1. Assumption 5 was assured because all fish were rigorously examined for excised adipose fins and the upper and lower lobes of the caudal fin.

Water temperature was monitored during this experiment because other studies suggested that larger rainbow trout were more likely to avoid shallow water (< 2 m deep) at temperatures near and exceeding 20°C. This behavior could violate one of the conditions for Assumption 2. Also, captured fish were stressed more by temperatures $\geq 20°C$ and were less likely to recover from handling during sampling and marking procedures. This situation would violate Assumption 3. For this study we decided that all capture effort would stop if the temperature exceeded 18°C.

Chapman's modification of the Petersen estimator (Chapman 1951; Seber 1982) was used to estimate the abundance of the rainbow trout population:

$$\hat{N} = \frac{(n_1 + 1)(n_2 + 1)}{(m_2 + 1)} - 1 \tag{1}$$

where:

$\hat{N}$ = the abundance of rainbow trout;

n_1 = the number of rainbow trout marked and released during Event 1;

n_2 = the number of rainbow trout examined for marks during Event 2; and,

m_2 = the number of rainbow trout marked during Event 1 that were recaptured during Event 2.

Variance of Chapman's modified estimator was calculated using (Seber 1982; Wittes 1972):

$$V\left[\hat{N}\right] = \frac{(n_1 + 1)(n_2 + 1)(n_1 - m_2)(n_2 - m_2)}{(m_2 + 1)^2 (m_2 + 2)}. \tag{2}$$

RESULTS AND DISCUSSION

During Event 1, 149 rainbow trout were captured, marked, and released (Figure 17). During Event 2, 196 rainbow trout were captured and examined for marks (Figure 17), 55 of which were recaptured (Figure 17). Rainbow trout captured during Event 2 ranged in size from 245 to 350 mm FL (with one outlier at 396 mm), mean length was 294 mm FL (SE = 1.32). During both events 495 age-0 rainbow trout were captured but none were given marks and none were included in this study. Age-0 fish were less than 200 mm FL. Water temperature during both events was < 12°C 1 m below the surface.

Plots of cumulative frequency distributions (CFDs) were generated from lengths of fish captured during both events (Figure 18). Test results for size selectivity (Appendix C) indicated that there was no significant size bias during Event 1 (D=0.073, P=0.950) and stratification by size was not required prior to estimating abundance.

Test results for consistency of capture probabilities by area were not conducted because no fish were captured in Area I. A single unstratified Petersen type estimator was appropriate for estimating abundance. The estimated abundance was 527 (SE=47) age-2 and older rainbow trout.

We inferred from visual inspection of the length frequency distribution and stocking history that only one rainbow trout captured during this study was likely age 3. All other rainbow trout larger than 200 mm were age 2. Subsequently, we were not able to evaluate size bias sampling as a function of differential age class vulnerability to sampling gear (Research Objective 2).

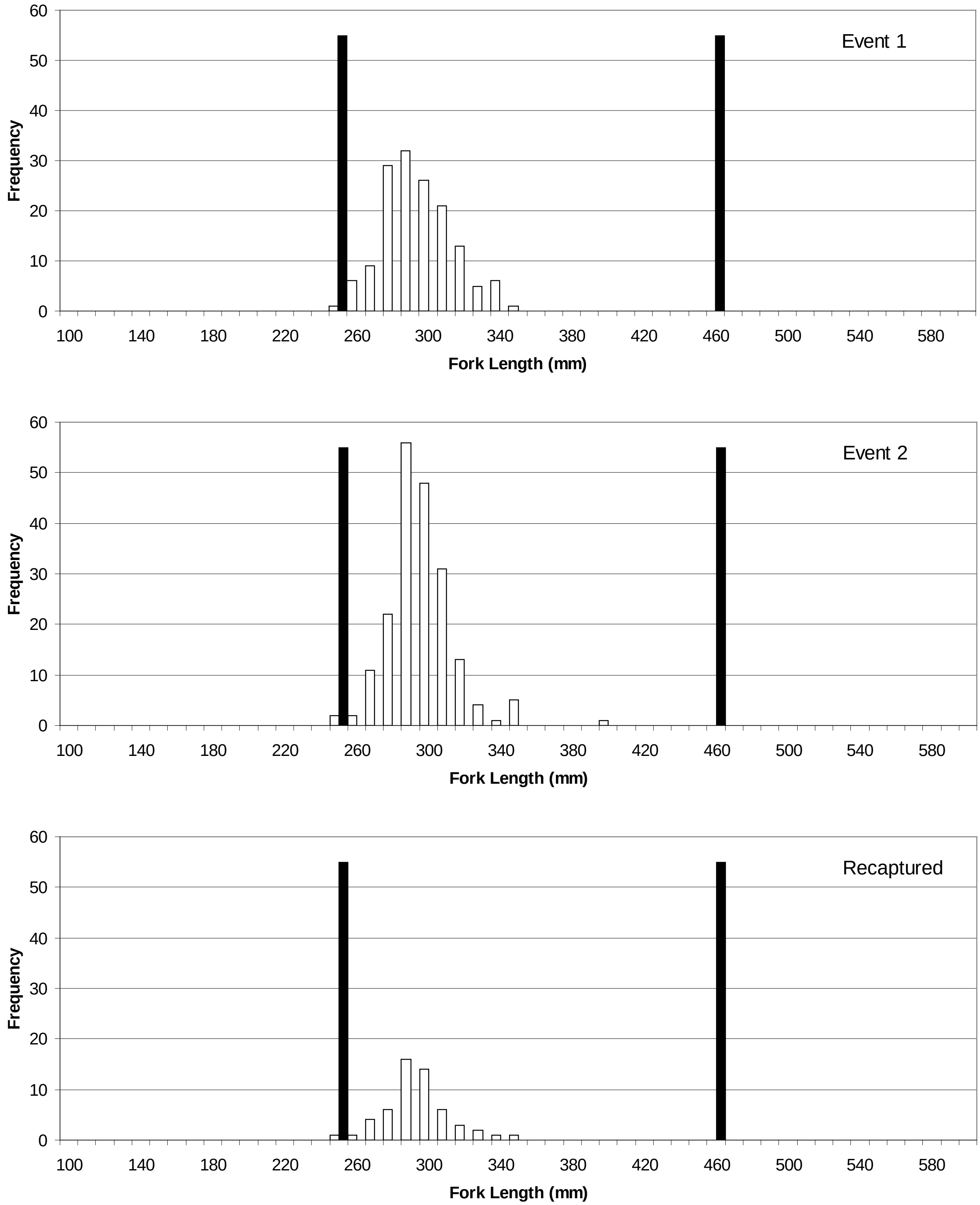

Figure 17.–Lengths of rainbow trout captured during Lisa Lake mark-recapture experiment.

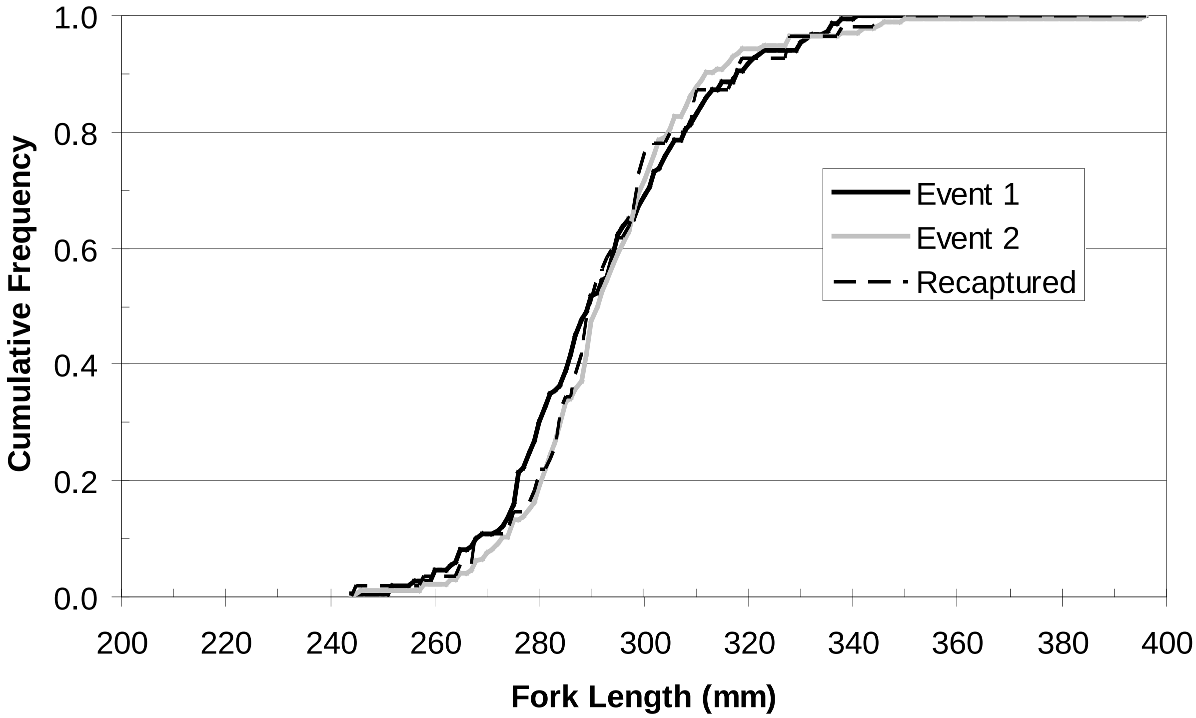

Figure 18.–Cumulative frequency distributions of lengths for rainbow trout captured during the mark-recapture experiment at Lisa Lake.

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APPENDIX A
COUNTS OF RAINBOW TROUT CAPTURED BY GEAR TYPE

Appendix A.–Counts of fish captured by gear type. Length range (mm FL) of fish captured by gear type in parentheses.

Lake	Species	Fyke Net	Tangle Net	Hoop Net[a]	Total
Backdown L	RT	52 (125-289)	0	N/A	52
	AC	23 (126-310)	0	N/A	23
Coalmine #5 L	RT	31 102-454	0	N/A	31
	LT	1 (250)	0	N/A	1
	LS	1 (186)	0	N/A	1
Dune L	RT	566 (108-656)	1 (464)	N/A	567
	GR	386 (306-512)	13 (373-420)	N/A	399
Firebreak L		Winterkill – no fish captured			
Jan L	RT	98 (200-351)	0	N/A	98
	SS	137 (171-200)	1 (189)	N/A	138
Last L		Winterkill – no fish captured			
Lisa L	RT	288 (244-396)	2 (290-310)	N/A	290
	YOY RT[b]	30 (58-76)	0	N/A	30
Tolsona Mt. L	RT	70 (175-395)	2 (367-370)	N/A	72
	YOY RT[b]	4 (46-65)	0	N/A	4
Triangle L	RT	13 (241-568)	2 (431-466)	N/A	15
Triangle L	BF	4 (42-95)[c]	0	2 (67-81)[c]	6
West Iksgiza L	RT	130 (184-468)	20 (223-284)	N/A	150

[a] Hoop nets were used only in Triangle Lake.

[b] Young of the year – fish not used in data analysis.

[c] mm total length.

Species Codes:

RT – Rainbow Trout (*Oncorhynchus mykiss*)
AC – Arctic Char (*Salvelinus alpinus*)
GR – Arctic Grayling (*Thymallus arcticus*)
SS – Coho Salmon (*Oncorhynchus kisuth*)
BF – Alaska Blackfish (*Dallia pectoralis*)

APPENDIX B
LAKE STOCKING HISTORIES

Appendix B.–Stocking histories from 2000–2006 for lakes sampled in 2006.

Lake	Species	Date	Number	Avg. Length (mm)
Backdown	RT	1-Aug-2000	1,227	46
Backdown	RT	14-Aug-2002	992	51
Backdown	AC	4-Sep-2002	663	91
Backdown	RT	2-Aug-2004	1,200	43
Backdown	RT	18-Aug-2004	325	163
Backdown	AC	19-Aug-2004	450	66
Backdown	AC	24-Aug-2005	450	91
Coal Mine #5	RT	7-Jun-1999	333	262
Coal Mine #5	RT	8-Aug-2001	2,000	46
Coal Mine #5	RT	2-Aug-2004	2,000	43
Coal Mine #5	RT	18-Aug-2004	540	163
Dune	RT	22-Jul-1999	10,000	51
Dune	SS	27-Jun-2000	8,836	76
Dune	GR	29-Aug-2000	10,794	48
Dune	RT	29-Aug-2000	5,009	71
Dune	RT	6-Aug-2001	15,000	43
Dune	SS	9-Jul-2002	3,000	71
Dune	GR	9-Jul-2002	10,000	20
Dune	GR	6-Aug-2003	10,016	46
Dune	RT	6-Aug-2003	9,000	43
Dune	SS	24-Jun-2004	3,962	58
Dune	GR	29-Jul-2004	10,000	41
Dune	RT	3-Aug-2005	11,000	41
Firebreak	RT	6-Aug-2001	10,000	43
Firebreak	RT	6-Aug-2003	10,009	46
Firebreak	RT	3-Aug-2005	10,000	41
Jan	RT	14-Jul-2004	9,000	48
Jan	RT	3-Aug-2001	9,000	43
Jan	SS	30-Jul-2002	9,000	76
Jan	SS	3-Jun-2003	9,000	66
Jan	RT	30-Jul-1999	9,036	56
Jan	SS	8-Jun-2005	3,922	66
Jan	SS	8-Jun-2005	8,000	46
Last	AC	22-Sep-1999	503	114
Last	RT	1-Aug-2000	1,227	46
Last	RT	14-Aug-2002	992	51
Last	AC	4-Sep-2002	663	91
Last	RT	2-Aug-2004	1,200	43
Last	RT	18-Aug-2004	325	163
Last	AC	19-Aug-2004	450	66
Last	AC	24-Aug-2005	450	91

-continued-

Appendix B.–Page 2 of 2.

Lake	Species	Date	Number	Avg. Length (mm)
Lisa	RT	26-Jul-1999	10,000	53
Lisa	RT	3-Aug-2001	10,000	43
Lisa	RT	20-Aug-2003	10,000	51
Lisa	RT	14-Jul-2004	9,000	48
Triangle	RT	22-Jul-1999	10,133	51
Triangle	RT	6-Aug-2001	10,000	43
Triangle	RT	6-Aug-2003	10,001	46
Triangle	RT	3-Aug-2005	10,000	41
West Iksgiza	RT	29-Jul-2004	10,033	43
West Iksgiza	RT	13-Sep-2005	10,796	58
Tolsona Mt.	RT	20-Aug-1999	15,000	61
Tolsona Mt.	RT	3-Aug-2001	15,000	43
Tolsona Mt.	RT	6-Aug-2004	15,008	48

Species Codes:

RT Rainbow Trout
SS Silver Salmon
AC Arctic Char
GR Arctic Grayling

APPENDIX C
TESTS OF SIZE SELECTIVITY AND CONSISTENCY FOR PETERSEN ESTIMATOR

TEST OF SIZE SELECTIVITY IN PETERSEN ESTIMATOR

Size selective sampling was tested with a two sample Kolmogorov-Smirnov (K-S) test (Conover 1980) generated from length data collected during the marking and recapture events. Lengths of fish captured during Event 2 were tested against lengths of fish marked in Event 1 and recaptured during Event 2.

> H_o for this test is: The distribution of lengths for fish recaptured during Event 2 is the same as the distribution of lengths for all fish captured during Event 2.

If no significant difference was detected between these two samples equal probability of capture in Event 1 was indicated and all data were pooled to calculate one unstratified population estimate. If a significant difference was detected, it was assumed that a size stratified estimator was required because no robust testing procedure is available to evaluate size selective sampling during Event 2. Data from both sampling events would be stratified into two or more size strata such that no significant difference was detectable when the K-S test described above is repeated within strata. Abundance would then be estimated for each size stratum and the estimates and variances would be summed for an overall abundance estimate. Size composition parameters would be estimated for each stratum, and then combined weighted by estimated abundance in each stratum. This decision protocol for stratification is conservative, in that stratification may be used when it is actually unnecessary due to equal probability of sampling during Event 2. However, the loss in precision from using stratified estimation when it is unnecessary is relatively small, and potential bias due to size bias sampling is prevented.